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Artificial Intelligence in Theater: *A Review* of Developments, Challenges, and Research Opportunities

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Abstract: Objective: To investigate the applications, technological progress, and principal challenges of Artificial Intelligence (AI) in theater, and to identify gaps and opportunities for future research. **Method:** A systematic literature review was conducted by retrieving studies from Scopus, Web of Science, IEEE Xplore, and JSTOR. Thirty peer-reviewed articles were selected based on predefined inclusion and exclusion criteria, followed by manual screening and qualitative content analysis. **Results:** The analysis indicated that AI-driven script generation achieves promising outcomes but struggles with maintaining stylistic consistency and emotional depth. AI-powered character interaction systems enhance audience immersion, yet encounter limitations in real-time responsiveness and preservation of creative control. Machine-learning-based audience engagement platforms improve interactivity but exhibit uneven adaptability across diverse theatrical contexts. **Conclusion:** Although AI shows considerable potential to transform writing, performance dynamics, and audience participation in theater, critical issues remain in safeguarding creative autonomy, ensuring coherent integration with traditional theatrical conventions, and balancing automated processes with human artistry. **Recommendations:** Future work should pursue deeper interdisciplinary integration of AI and classical theater practices; develop customizable AI tools that grant directors and performers greater creative agency; optimize AI applications in stage design and technical production; and undertake cross-cultural, multi-venue empirical studies to validate system robustness and artistic impact.

Keywords: Artificial Intelligence (AI), Theater, Technological Advances, Creative Process, Interdisciplinary Collaboration.

الذكاء الاصطناعي في المسرح :مراجعة للتطورات والتحديات وفرص البحث

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الملخص: الهدف :تهدف هذه الدراسة إلى استقصاء تطبيقات الذكاء الاصطناعي في المسرح، وتقدمه التكنولوجي، والتحديات الرئيسية المصاحبة، فضلاً عن تحديد الثغرات وفرص البحث المستقبلية. **المنهج :**أُجريت مراجعة منهجية للأدبيات عبر قواعد بيانات Scopus و Web of Scienceو IEEE Xploreو JSTOR، وتم اختيار ثلاثين مقالة محكمة وفق معايير إدراج واستبعاد محددة مسبقًا، أعقب ذلك فرز يدوي وتحليل نوعي للمحتوى. **النتائج الرئيسية:** أظهرت التحليلات أن تقنيات توليد النصوص المدعومة بالذكاء الاصطناعي تحقق نتائج واعدة لكنها تواجه صعوبات في الحفاظ على التناسق الأسلوبي والعمق العاطفي؛ كما تعزز أنظمة التفاعل مع الشخصيات انغماس الجمهور لكنها تواجه قيودًا في الاستجابة الفورية وصون السيطرة الإبداعية؛ فيما حسنت منصات التفاعل القائمة على تعلم الآلة مستوى التفاعلية لكنها تعاني تفاوتًا في قدرتها على التكيف عبر السياقات المسرحية المتنوعة .**الخلاصة:** بالرغم من الإمكانات الكبيرة للذكاء الاصطناعي في تحويل عمليات الكتابة وديناميكيات الأداء ومشاركة الجمهور، تظل قضايا صون الاستقلالية الإبداعية وضمان التكامل المتجانس مع التقاليد المسرحية وتحقيق التوازن بين الأتمتة والفن البشري تحديات أساسية. **التوصيات:** يُوصى بتعزيز التكامل بين الذكاء الاصطناعي والممارسات المسرحية الكلاسيكية عبر التخصصات؛ وتطوير أدوات قابلة للتخصيص تمنح المخرجين والمؤدين مزيدًا من الوكالة الإبداعية؛ وتحسين تطبيقات الذكاء الاصطناعي في تصميم المنصات والإنتاج التقني؛ وإجراء دراسات ميدانية متعددة الثقافات ومتعددة المواقع للتحقق من متانة الأنظمة وأثرها الفني

الكلمات المفتاحية: الذكاء الاصطناعي (AI) المسرح؛ التقدم التكنولوجي؛ العملية الإبداعية؛ التعاون متعدد التخصصات.

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Introduction

In recent years, artificial intelligence (AI) technology has experienced rapid advancements across industries such as manufacturing, healthcare, finance, and education (Dwivedi *et al*., 2019; Krittanawong & Kaplin, 2021). From early expert systems to modern deep learning and large models, AI has demonstrated immense potential across various sectors (Konya & Nematzadeh, 2024; Masalkhi *et al*., 2024; Wei *et al*., 2024). In the realms of arts and cultural creativity, AI has increasingly permeated areas such as music generation, visual art creation, and literary composition, continuously expanding the boundaries of the integration between human creativity and technology (Epstein *et al*., 2023). Compared to other art forms such as music and visual arts, theater integrates multiple elements, including playwriting, directing, acting, scenography, and audience interaction, making it more demanding in terms of the creative process and live performance environment (Eacho, 2023). Although recent years have witnessed some research and practical applications of AI in areas such as automated script generation, character interaction, intelligent stage management, and audience feedback analysis, these efforts remain in the exploratory stage (Befera, 2023). Most are isolated case studies or proof-of-concept experiments, lacking a systematic analysis of the overall development trajectory(Curtis, 2025; Kelomees *et al*., 2024). This has resulted in fragmented research outcomes, limiting the provision of clear strategic guidance for the deeper integration of AI with theater arts (Peng *et al*., 2024; Thomas, 2024; Walton, 2021).

With the advancement of AI, its application in the arts has garnered increasing attention, particularly in theater, an art form that emphasizes real-time performance and emotional exchange (Tait, 2025). AI has demonstrated potential in scriptwriting, character interaction, stage management, and audience engagement(Çelik, 2024; Tang *et al*., 2025). However, existing studies remain fragmented, lacking a comprehensive synthesis of AI's role in theatrical production and performance (Cai *et al*., 2020; Walton, 2021). Most research focuses on specific aspects, such as AI-assisted script generation (Garcia, 2024), virtual character interaction (Mathewson & Mirowski, 2021)(Ren, 2024), and stage optimization (Mirowski *et al*., 2023), without offering a holistic view of AI-driven theater's development, challenges, and future directions.

This study addresses this gap by conducting a systematic literature review to examine AI applications in theater. By synthesising findings from sources including Scopus, Web of Science, IEEE Xplore, and JSTOR, this paper constructs a research framework that maps AI's role in theatrical creation and performance. The novelty of this study lies in its first attempt to systematically integrate research across different domains of AI-driven theater, providing a structured understanding of its development. The significance of this research is threefold: (1) it offers a comprehensive overview of AI's integration into theater, addressing the existing fragmentation in the literature; (2) it provides practical insights for industry professionals regarding AI's potential applications in theater production; and (3) it establishes a theoretical

foundation for future interdisciplinary research in AI and theater.

This study employs a systematic literature review approach to provide a structured synthesis of AI applications in theater(Bandara & Syed, 2024). By establishing predefined search strategies and rigorous inclusion and exclusion criteria, relevant literature from Scopus, Web of Science, IEEE Xplore, and JSTOR between 2019 and 2025 has been analyzed (Noh *et al*., 2015). The review categorizes AI applications into script generation, character interaction, audience engagement, and stage management, identifying development trends, technological advancements, and innovative practices. Additionally, selected case studies are examined to offer empirical insights supporting theoretical discussions.

This study aims to address the lack of a comprehensive evaluation in this interdisciplinary domain. By systematically summarizing existing challenges and future research directions, the review provides theoretical guidance for researchers and practical insights for industry professionals. It seeks to foster deeper integration of AI into theatrical production while preserving the core artistic essence of theater (Mirowski *et al*., 2025). Furthermore, by reducing the information asymmetry between technological and artistic disciplines, this study contributes to minimizing trial-and-error costs in AI-driven theater innovation.

To explore the intersection of AI and theater, this study focuses on the following key research questions:

1. What is the maturity level of AI applications in scriptwriting, character interaction, audience engagement, and stage management? What are the predominant technological approaches and emerging trends in these areas?
2. What are the primary technological, artistic, and ethical challenges associated with integrating AI into theater?
3. How can AI contribute to the evolution of theatrical forms while preserving the core artistic values of theater?

By systematically addressing these research questions, this study provides valuable insights into the current landscape, challenges, and future potential of AI in theater, offering a foundation for both academic inquiry and practical applications in the performing arts.

Literature Review

In the following section, this paper first presents the literature review and then discusses the limitations of existing studies.

Overview of Existing Research: In recent years, research in the field of AI-driven theater has been steadily increasing, covering areas such as script generation, stage performance, and audience interaction (Eacho, 2023). This review synthesizes current research outcomes from both temporal and thematic perspectives while revisiting several seminal studies to highlight their contributions and limitations（Al-Aghbari, Alkharusi, & Al Fazari, 2025）.

The review of studies from 2019 to 2025 reveals a clear developmental trajectory. The early phase (2019–2020) was characterized by technological feasibility and initial exploration. Projects like Mirowski's Improbotics (2019)

validated AI's capacity to generate dialogue for improvisational performances, yet they exposed limitations in emotional depth and narrative coherence(*Improbotics Artificial Intelligence Improvisation at Brighton Fringe 2023*). Decheva (2020) explored interactive systems, which demonstrated potential but encountered challenges in achieving real-time responsiveness and fluidity. These pioneering efforts, although experimental in nature, primarily focused on proving AI's potential in theatrical settings without fully addressing the inherent complexities of artistic creation.

Advancements accelerated during 2021–2022 as the focus shifted towards large-scale applications and the development of theoretical frameworks. Rosa's THEaiTRE project (2022) marked a breakthrough by generating 90% of the script content using AI(Rosa *et al*., 2022), thereby significantly enhancing creative efficiency; simultaneously, the classification framework proposed by Befera and Bioglio (2022) laid the groundwork for systematically evaluating the integration of technology and art. Despite these breakthroughs, challenges related to the coherence of complex narratives and the emotional depth of character development persisted, indicating that the technological progress had yet to fully align with the demands of artistic expression (Befera, 2023).

From 2023 onward, research further expanded the multidimensional applications of AI in theater. Ren's work (2024) on large language models in script generation highlighted ongoing challenges in maintaining narrative coherence and rich emotional expression (Liu *et al*., 2024). Concurrently, Hessam (2024) explored the integration of augmented reality (AR) and virtual reality (VR) in stage design, emphasizing the potential for personalized artistic experiences while also noting the complexities of multi-technology integration (Djavaherpour *et al*., 2024). Cicconi's Enhanced Panoramic Theater project (2024) showcased the innovative combination of generative AI with multimodal technologies, though it also raised questions regarding its broad applicability and cultural adaptability (Lih, 2024). These developments underscore that, despite significant technological breakthroughs, enduring challenges in emotional expression, technological integration, and ethical considerations remain.

The thematic analysis of the literature further illuminates trends within the field by focusing on script generation, character interaction, and audience immersion. In the domain of script generation, the research by Rosa and Ren demonstrates that although AI is capable of generating large-scale script content and enhancing creative efficiency, limitations in conveying nuanced emotions and constructing complex narratives necessitate continued human involvement. In the area of character interaction, projects like Mirowski's Improbotics and Maiti's work on motion capture technology (2024) illustrate AI's potential for real-time engagement, yet significant gaps persist in achieving natural emotional dynamics and compelling resonance; furthermore, Thomas (2024) points to ethical challenges concerning AI-synthesized characters and identity manipulation, emphasizing the importance of safeguarding performers' rights as technology advances. With regard to audience

immersion, studies by Pizzo (2021) and Cicconi (2024) demonstrate that multimodal technologies such as AR can create highly engaging theatrical experiences, though issues related to privacy protection and cultural adaptation remain; Du's research into AI-driven audience engagement systems further reveals the potential for personalized theat experiences, despite the need for further exploration of their long-term societal impact （Haddad & Al-Refai, 2015）.

In summary, the field of AI-driven theater has evolved from initial technological validation to large-scale, multidimensional applications. While AI has significantly enhanced creative efficiency and audience engagement, persistent challenges—particularly in emotional expression, technological integration, and ethical adaptability—point to critical directions for future research.

Review of Related Literature: As AI technologies become increasingly integrated into theatrical productions, developing robust evaluation methods and standards to assess their effectiveness and artistic value is essential (Gill *et al*., 2024). Existing studies largely rely on a combination of qualitative and quantitative approaches; however, several shortcomings remain evident (Pilcher & Cortazzi, 2024). Many studies primarily use case analyses, interviews, and expert assessments to evaluate aspects such as script generation, character interaction, and audience engagement. While these qualitative methods capture nuanced artistic expressions and audience experiences, they depend heavily on subjective judgments, making it difficult to compare findings across different studies (Chen *et al*., 2023; Coleman *et al*., 2019).

On the quantitative side, some research has attempted to incorporate measures such as sentiment analysis, physiological indicators (e.g., heart rate and EEG), and evaluations of textual coherence and emotional consistency (Pilcher & Cortazzi, 2024). Yet, these metrics are still in the exploratory stage and have not yet evolved into a mature, widely accepted system that effectively captures the relationship between technical performance and artistic expression (Zhou & Lee, 2024).

Moreover, assessments of technical performance, artistic quality, and audience experience are often conducted separately, lacking a unified, multidimensional evaluation framework (Chang *et al*., 2024; Danish *et al*., 2025). This fragmented approach limits our ability to fully understand and compare the overall impact of AI-driven theater applications.

Therefore, future research should aim to construct an integrated evaluation framework that combines objective quantitative metrics with qualitative insights. Such a framework would enable more rigorous comparisons across studies and provide a clearer picture of how AI technologies contribute to theatrical creativity, ultimately guiding improvements in both theory and practice.

Gaps in Research on Theater and AI: The following section provides an in-depth analysis of the issues and gaps identified in the existing literature regarding AI-driven theater.

Technological integration is a crucial aspect of applying AI in theater, yet existing studies reveal several technical limitations (Fuoco, 2024). First, the expression of complex emotions

and narrative coherence remains a significant challenge. Ren and Rosa highlighted that while large language models (LLMs) demonstrate high efficiency in generating dialogues and storylines, they still struggle with conveying intricate emotions and maintaining coherence in multi-character narratives (Zhang *et al*., 2024). These limitations significantly constrain the expressive capabilities of AI in complete theatrical creation (Subbiah *et al*., 2024). Additionally, issues related to real-time collaboration and fluidity in human-AI interaction are prominent. For example, Mirowski's Improbotics project demonstrated the potential of AI in generating real-time dialogue for improvisational performances; however, the generated content often lacked contextual adaptability and natural emotional flow, thereby undermining overall performance coherence(Chow *et al*., 2019). Similarly, challenges in multimodal interactions have been noted—independent functioning of technologies such as motion capture, language generation models, and stage lighting design hinders seamless cross-technology collaboration (Nixon & Bektimirova). Furthermore, the complexity of cross-technology integration is evident in practical obstacles such as the compatibility of different hardware platforms and the high demand for computational resources. Real-time data transmission between motion capture technologies and VR systems, for instance, requires highly efficient computational support, yet theater environments often lack industrial-grade computing facilities (Fanini & Cinque, 2019). In summary, these challenges not only hinder the comprehensive application of AI in theater but also expose unresolved structural contradictions in the fusion of technology and art (Baraybar-Fernández, 2025). Future research must focus on developing unified cross-technology integration frameworks while optimizing hardware compatibility and resource allocation.

The widespread application of AI technology also poses new challenges to artistic freedom in creation. In projects like THEaiTRE, as the proportion of AI-generated script content increased, the boundaries of creative authorship became increasingly blurred, making it difficult to define the specific role of human playwrights (Rosa *et al*., 2022). Similarly, AI-generated content often exhibits templated characteristics, lacking the personalized and creative expression essential for a diverse theatrical landscape. This tendency risks narrowing the artistic space available to human creators, potentially leading to a homogenization of theatrical works (Rosa, 2022). Moreover, studies have shown that AI-driven character performances frequently lack the artistic impact necessary for seamless integration with human performers' styles, underscoring the need to strike a balance between leveraging AI to assist creation and safeguarding artistic freedom in theatrical production.

Ethical issues represent another critical gap in the current literature. The application of AI in theater has triggered concerns across performance ethics, data ethics, and cultural ethics (Thomas, 2024). With respect to performance ethics, issues such as identity manipulation and unauthorized use of actors' likenesses in AI-synthesized performances can infringe on performers' rights, particularly in the

absence of clear legal frameworks or industry standards (Eshraghian, 2020). In the realm of data ethics, the real-time collection and analysis of audience data, necessary for optimizing interactive experiences, raises potential risks of privacy breaches and data misuse, which could lead to excessive monitoring and erosion of public trust (Deng *et al*., 2021). Additionally, most current AI systems are trained on datasets rooted in Western cultural contexts, limiting their effectiveness in non-Western theatrical creations and risking further homogenization of cultural expression (Peters & Carman, 2024). These ethical concerns highlight the complexity and potential risks associated with the integration of AI in theater, emphasizing the need for systematic ethical standards that protect performers' rights, ensure transparent data regulation, and enhance cross-cultural adaptability.

Despite significant advancements in applying AI in theater, there remains a notable absence of robust evaluation frameworks. Currently, there are no clear standards for assessing the artistic value and audience acceptance of AI-generated content, leading to subjective evaluations of artistic quality (Chen *et al*., 2023; Coleman *et al*., 2019; Zhou & Lee, 2024). This subjectivity undermines both academic research and the credibility of technological outcomes by leaving audience recognition of AI-generated results without a solid scientific foundation. Moreover, while classification frameworks proposed in the literature hold theoretical value in organizing technological pathways, they often fail to provide horizontal comparisons across different approaches, limiting their utility for optimizing multi-technology integration. The lack of multidisciplinary perspectives, such as psychological or sociological analyses, further contributes to an insufficient understanding of the effects of AI technologies on emotional expression and audience immersion. This gap not only hinders the sustainable optimization of AI technologies in theater but also weakens the scientific foundation necessary for integrating art and technology (Wu, 2022). Future research should prioritize developing standardized evaluation systems that quantitatively measure dimensions such as artistic value, audience acceptance, and technological performance while incorporating multidisciplinary insights.

In summary, while the field of AI-driven theater has made certain advancements in technological applications and theoretical frameworks, significant gaps remain in key areas such as technological integration, creative freedom, ethical standards, and evaluation frameworks. These issues not only limit the depth and breadth of AI applications in theater but also expose fundamental challenges in the integration of technology and art. Future research should focus on optimizing multimodal integration capabilities, establishing collaborative mechanisms that clearly define creative agency while accommodating personalization, developing systematic ethical guidelines and evaluation frameworks, and leveraging interdisciplinary perspectives to promote a deeper fusion of technology and art.

Research Design

This chapter outlines the research design of the study, including the research methods, review

process, and classification framework.

Research Methods and Research Questions: This review aims to provide a comprehensive analysis of both theoretical and practical developments in AI-Driven Theater. To achieve this, we employ a systematic literature review (SLR) framework, which allows us to explore current applications of AI in script generation, character interaction, audience engagement, and stage management, as well as identify challenges and future opportunities (Cabrera & Cabrera, 2023).

Systematic literature reviews are widely recognized in interdisciplinary research for their structured, transparent, and reproducible methodology. Following PRISMA guidelines (Page *et al*., 2023), we designed a rigorous protocol with predefined search strategies, inclusion/exclusion criteria, and standardized data extraction to map trends and critical issues in the field. This approach establishes a robust theoretical and empirical foundation for understanding AI-Driven Theater.

Review Process and Literature Retrieval Methods: To fully capture the theoretical and practical dynamics of AI-Driven Theater, this paper adopts a methodological framework combining Systematic Literature Review (SLR) and case study analysis. This approach aims to reveal the current applications, challenges, and future potential of AI in scriptwriting, character interaction, audience engagement, and stage management through structured, transparent literature retrieval and rigorous case evaluations.

First, this study employs the Systematic Literature Review (SLR) method. SLR is highly regarded in interdisciplinary research for its structured, transparent, and reproducible nature. Its core strength lies in predefined search strategies, strict inclusion/exclusion criteria, and standardized data extraction, enabling a comprehensive exploration of research trends and critical issues in complex fields (Cabrera & Cabrera, 2023).

To ensure rigour, this review follows the PRISMA guidelines in designing the search and screening process. The literature search is conducted across four major academic databases: Scopus, Web of Science, IEEE Xplore, and JSTOR, covering fields such as computer science, performing arts, and social sciences. The search strategy uses Boolean logic to design targeted keywords addressing the review's three research questions: For examining AI applications in script generation, character interaction, audience engagement, and stage management, keywords include: "artificial intelligence," "AI," "script generation," "character interaction," "audience engagement," and "stage management." For investigating technical, ethical, and artistic challenges in AI-driven theater production and performance, terms include: "technical challenges," "ethical issues," and "artistic challenges." For exploring future transformation and bottlenecks, keywords include: "innovation," "transformation," "future prospects," and "bottlenecks." All search steps are documented in detail, and the publication date range is limited to 2019–2025 to capture the latest developments in AI-driven theater. The initial search yielded 19,319 records (table 1).

Table (1): Search Process.

Database	Results	Keyword search and other applied filters
Scopus	7434 articles	TITLE-ABS-KEY(("artificial intelligence" OR "AI") AND ("script generation" OR "character interaction" OR "audience engagement" OR "stage management") AND ("technical challenges" OR "ethical issues" OR "artistic challenges") AND ("innovation" OR "transformation" OR "future prospects" OR "bottlenecks")) AND PUBYEAR > 2019 AND PUBYEAR < 2025
Web of Science	6232 articles	TS=(("artificial intelligence" OR "AI") AND ("script generation" OR "character interaction" OR "audience engagement" OR "stage management") AND ("technical challenges" OR "ethical issues" OR "artistic challenges") AND ("innovation" OR "transformation" OR "future prospects" OR "bottlenecks")) AND PY=(2019-2025)
IEEE Xplore	51 articles	("artificial intelligence" OR "AI") AND ("script generation" OR "character interaction" OR "audience engagement" OR "stage management") AND ("technical challenges" OR "ethical issues" OR "artistic challenges") AND ("innovation" OR "transformation" OR "future prospects" OR "bottlenecks")
JSTOR	5602 articles	("artificial intelligence" OR "AI") AND ("script generation" OR "character interaction" OR "audience engagement" OR "stage management") AND ("technical challenges" OR "ethical issues" OR "artistic challenges") AND ("innovation" OR "transformation" OR "future prospects" OR "bottlenecks")

In the literature screening process, this study employs a semi-automated and manual screening approach. First, reference management tools (e.g., Mendeley) are used to deduplicate and organize the initial 19,319 records. After removing duplicates and irrelevant publications, 18,889 articles remain. Next, preliminary screening is conducted based on predefined inclusion/exclusion criteria, including discipline, publication type, research focus, and thematic relevance. This reduces the pool to 85 articles. Finally, full-text articles are assessed for methodological quality using the CASP checklist (Nadelson & Nadelson, 2014). The CASP tool evaluates: clarity of research objectives, appropriateness of methodology, sampling strategy, data collection and analysis, and ethical considerations. Each article is independently scored by two reviewers. Discrepancies are resolved through discussion. Through this rigorous process, 30 high-quality studies directly relevant to script generation, character interaction, audience engagement, and stage management are selected as the core dataset (table 2). The search workflow is illustrated (figure 1).

Table (2): Semi-Automatic Filtering Results and Manual Checking.

Source	Original	Semiautomatic	Manual checking
Scopus	7434 articles	114 articles	18 articles
Web of Science	6232 articles	24 articles	7 articles
IEEE Xplore	51 articles	25 articles	3 articles
JSTOR	5602 articles	5 articles	2 articles
Total	19319 articles	169 articles	30 articles

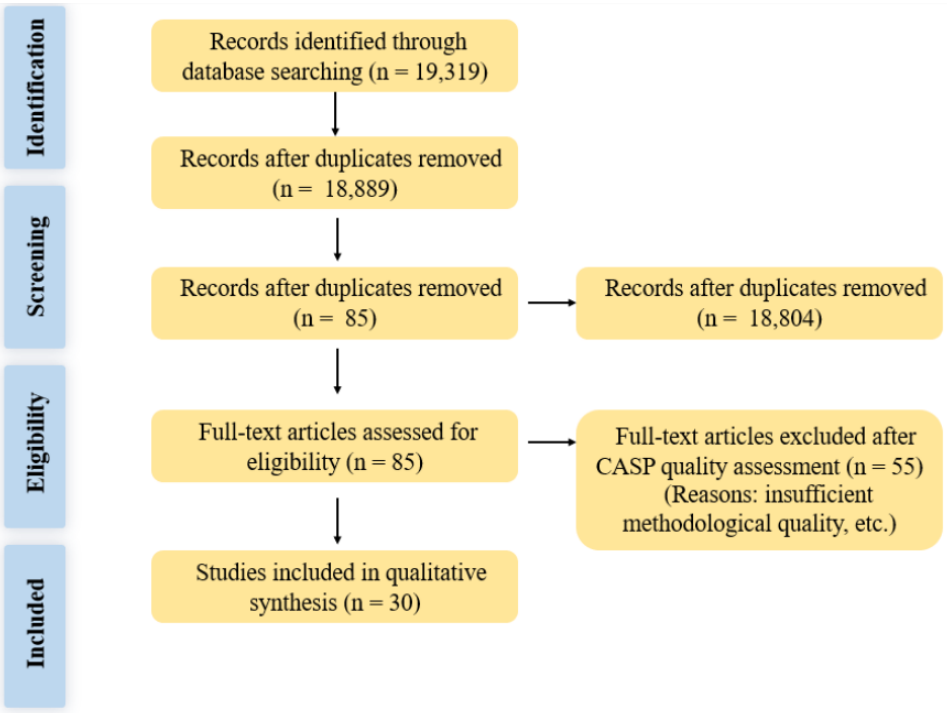

Figure (1): PRISMA Search workflow.

Literature Synthesis: After selecting the core documents, this study utilised Excel and NVivo tools to systematically classify and analyse the 30 core documents, constructing a multidimensional framework for literature synthesis while clarifying the classification criteria and standards.

First, the basic information of each document was recorded in an Excel spreadsheet, including fields such as title, author, publication date, research objectives, technological pathways, practical cases, and main conclusions. The documents were then preliminarily categorized based on their research focus, such as script generation, character interaction, audience engagement, and stage technology, providing structured data support for subsequent analysis.

Building on this foundation, NVivo software was employed to perform text coding on the full texts of the selected documents, systematically extracting core content related to the theme of AI-driven theater. To facilitate a deeper analysis of the content and trends within the selected literature, this study further developed a systematic sub-framework for synthesis, clearly defining the classification standards and definitions for each dimension:

Technological Advancements: This category includes four key directions: script generation, character interaction, audience engagement, and stage technology. Each direction focuses on improvements in technical performance and application scenarios. For instance, Rosa explored how generative AI achieves breakthroughs in emotional expression within multi-linear narrative creation, while Maiti examined how motion capture technology enhances the natural expressiveness of virtual characters. The categories are compiled (table 3).

Table (3): Framework for Summarizing Literature on Technology Dimensions.

Dimension	Focus Area	Classification Criteria
Technological Advances	Script Generation	Focus on improving technical performance and application scenarios.
	Character Interaction	Explore how technology enhances character performance.
	Audience Engagement	Examine how AI improves audience immersion and interaction.
	Stage Technology	Investigate AI applications in stage lighting, sound, and other technologies.

This dimension focuses on analyzing the common characteristics of successful cases and reflections on failed attempts. Classification criteria include whether the study explicitly identified technological application scenarios and whether it evaluated audience acceptance or artistic value. For example, Mirowski demonstrated the potential of AI technology in real-time feedback through stage performance case studies, while Walton analyzed how technological failures impacted the coherence of performances. The categories are compiled **خطأ! لم يتم العثور على مصدر المرجع.**).

Table (4): Framework for Summarizing Literature on Experience Dimensions.

Dimension	Focus Area	Classification Criteria
Practical Experiences	Successful Cases	Clearly defined application scenarios, evaluation of audience acceptance, or artistic value.
	Lessons from Failures	Reflection on technical bottlenecks or application issues.

This dimension highlights the practical challenges of technological integration (e.g., hardware compatibility and computational resource demands), ethical concerns (e.g., identity manipulation and privacy protection), and the absence of evaluation frameworks (e.g., lack of tools for quantifying artistic value and audience experience). For instance, Du identified challenges in integrating multimodal technologies, particularly hardware platform compatibility and high computational resource demands, which are especially pronounced in resource-constrained theatrical settings. Thomas provided an in-depth analysis of the potential threats to actor rights posed by identity manipulation and unauthorised performance generation, underscoring the need for transparent ethical regulatory frameworks. Additionally, Pizzo highlighted the lack of standardized tools for evaluating audience immersion experiences and emotional connections, noting that this gap not only undermines the rigor of academic research but also hampers the practical adoption of these technologies. The categories are compiled (Table (**5**).

Table (5): Framework for Summarizing Literature on Experience Dimensions.

Dimension	Focus Area	Classification Criteria
Research Gaps	Technical Integration Challenges	Hardware compatibility and high computational resource demands.
	Ethical Issues	Focus on identity manipulation, privacy protection, and the lack of transparent regulatory frameworks.
	Lack of Evaluation Tools	Absence of standardized tools for quantifying audience experience and artistic value.

This study further elaborates on the logical relationships within the classification framework: technological advancements provide the

technical foundation for practical experiences, while practical experiences validate the application effects of these technologies through case studies, simultaneously revealing challenges in integration and ethical issues, which ultimately constitute research gaps. The innovation of this classification framework lies in its systematic integration of the AI-driven theater field from three dimensions—technology, practice, and challenges—for the first time. It emphasises the dual pathways of combining technological functionality with artistic needs. This framework offers a structured analytical tool for subsequent research, supporting future theoretical and practical exploration in the AI-driven theater field.

In the framework, the insights gained from examining practical experiences naturally complement the identified research gaps. That is, while the empirical analysis of successful practices and lessons learned reveals how AI technologies are applied in real scenarios, it concurrently exposes specific issues in technology integration and ethical considerations. This integrated perspective provides a solid foundation for directing future research efforts, ensuring that practical findings are effectively linked to areas requiring further improvement.

By combining the data organization capabilities of Excel with the text coding and thematic analysis tools of NVivo, this study ultimately developed a systematic literature synthesis framework. This framework comprehensively encompasses the technological pathways, practical experiences, and research gaps in the AI-driven theater field, providing a solid foundation for the analysis in subsequent sections.

Results and Discussion

Application Status and Trends of AI in Script Creation, Character Interaction, Audience Engagement, and Stage Management: Our systematic literature review reveals distinct maturity levels across four main application areas of AI in the theater. Each area demonstrates different development stages and adoption patterns in theatrical practice.

Script creation shows moderate maturity, with approximately 30% of reviewed literature focusing on this application. These studies primarily examine pre-trained language models (such as the GPT series) for dialogue and plot generation. Several theaters have implemented human-AI collaborative writing platforms that help playwrights develop initial drafts more efficiently. For example, in 2021, London's Young Vic Theater staged an experimental play titled "AI" with partially AI-generated dialogue. While the generated content still required significant human editing, it demonstrated the potential of AI in script development (Befera & Bioglio, 2022). Recent advances in Transformer models have improved narrative coherence and character consistency, though the technology remains at an early adoption stage in professional theater.

Character interaction applications are at an experimental maturity level, discussed in about 25% of the literature. These studies explore conversational agents and real-time speech recognition to develop AI-driven character portrayals. Such virtual or robotic actors can interact with human performers and audiences during performances. While still primarily

confined to experimental productions, these applications have begun expanding traditional boundaries of theatrical characters. Current limitations include natural emotional expression and seamless multimodal interaction capabilities.

Audience engagement applications show early adoption maturity, featuring in approximately 20% of the literature. These systems use computer vision and emotion recognition to collect real-time audience data (facial expressions, heart rate) and dynamically adjust stage lighting, sound effects, or performance elements. Some immersive theater productions employ mobile applications or live voting to allow audience participation in plot decisions. While showing promise, these applications face challenges in data privacy and real-time processing requirements.

Stage management applications demonstrate varied maturity levels, appearing in 15-20% of publications. AI applications for rehearsal scheduling and ticket sales prediction show higher maturity (early mainstream adoption), while AI for stage design optimisation remains experimental. Larger theaters have successfully implemented AI in marketing and operational support, while artistic and performance applications are primarily used by experimental theater groups and avant-garde directors. Figure (2) illustrates these application areas and their relationships.

Based on our analysis, we can classify the overall maturity of AI in theater as follows: stage management applications (particularly in business operations) show the highest maturity level; script creation shows moderate maturity with growing adoption; audience engagement demonstrates early adoption primarily in experimental settings; and character interaction remains at the experimental stage with significant technical challenges still to overcome.

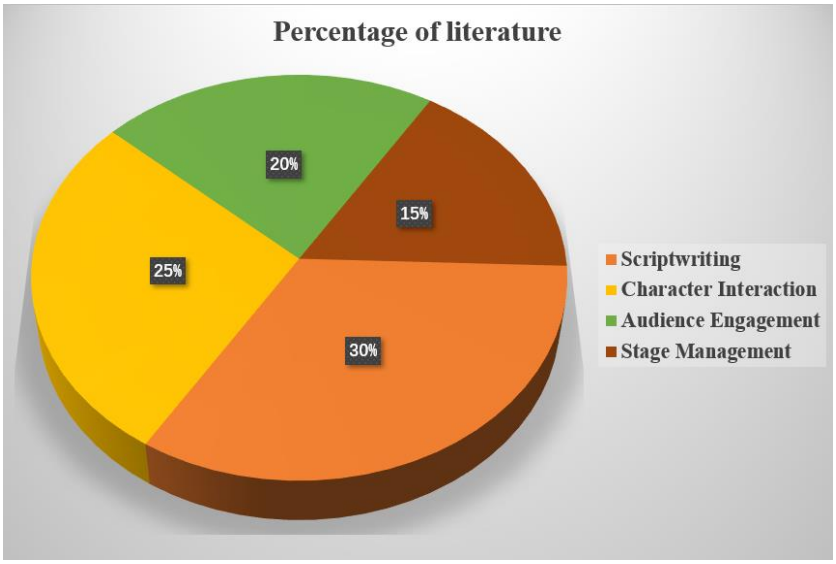

Figure (2): Percentage of Literature.

Application Challenges of AI in Theater: Our content analysis addressing the second research question reveals three categories of challenges mentioned across the literature.

Technical challenges appear in over 60% of articles, with researchers noting issues in content coherence, emotional expression, and limited training data. Real-time interactive systems face

difficulties in processing multimodal inputs and maintaining stability during live performances. These technical limitations reflect the experimental nature of many AI theater applications.

Ethical challenges receive attention in nearly half of the literature, particularly regarding copyright ownership, blurred creator identity, and potential job displacement concerns. Bias in training data also presents risks for cultural sensitivity in generated content. These ethical considerations are crucial for responsible AI integration in theatrical arts.

Artistic challenges, though mentioned less frequently, raise important concerns about the potential lack of emotional depth and individuality in AI-generated scripts or performances. These may lead to formulaic works that diminish artistic expression. Many scholars and artists advocate positioning AI as an "assistant" rather than the primary creator, helping with mechanical aspects while humans retain control over creative and aesthetic decisions.

The fundamental challenge remains to preserve the "human touch" and emotional impact of live theater while incorporating AI technologies. This balance serves as the ultimate criterion for judging successful AI applications in theater.

Barriers to AI Integration in Traditional Theater: Our analysis addressing the third research question identifies several significant barriers that impede AI integration in traditional theater while preserving core artistic values.

Current AI technologies struggle to interpret theater's deeper emotional and symbolic dimensions. This fundamental limitation results in generated content that lacks sufficient artistic depth. The technology cannot yet fully grasp the nuances of dramatic tension, subtle characterization, or the power of well-placed silence elements essential to theatrical storytelling.

The theater industry also faces a significant talent gap. Few professionals possess both technical expertise in AI and a deep understanding of theatrical arts. This shortage creates communication challenges between technical developers and artistic directors, often resulting in misaligned expectations and implementation difficulties. When technical and artistic teams operate in isolation, integration efforts frequently falter.

Additionally, the theater sector lacks unified standards and evaluation frameworks for AI applications. Without established guidelines, theaters approach AI adoption cautiously, unsure how to measure success or return on investment. This uncertainty makes it difficult for artistic directors to justify technological experimentation, especially when traditional methods have proven reliable

Economic barriers further restrict widespread adoption, particularly among smaller theater companies. The high costs of implementation and ongoing operation limit access to advanced AI tools. Consequently, technological innovation remains concentrated in well-funded institutions, creating an uneven landscape of AI adoption across the theater community. To overcome these barriers, the industry needs stronger cross-disciplinary collaboration mechanisms, accessible technical solutions, and shared evaluation frameworks. Only by addressing these challenges can AI truly

enhance theatrical innovation rather than diminishing its artistic essence.

Throughout this integration process, maintaining theatrical art at the core remains essential. Theater's fundamental value lies in its exploration of human experience and emotional resonance. This principle should guide all technological applications in the field. Future development should focus on creating a balanced partnership where AI supports artistic vision while human creators retain control over aesthetic decisions and creative direction.

Findings

Reflection on Research Findings and Significance: This study systematically analyzed the selected literature, addressing the research questions across three core directions: script generation, character interaction, and audience engagement. It revealed the current technological landscape and practical demands in the AI-driven theater field. Compared to the earlier literature review, this research focuses more on an in-depth analysis of core documents, systematically synthesizing the technological applications and artistic expressions in AI-driven theater and developing a multidimensional classification framework.

This framework, centered on script generation, character interaction, and audience engagement, highlights the coupling mechanisms between the functional features of AI and the artistic requirements of theater. Unlike previous studies, which often focused on a single technological pathway, this research expands understanding through cross-comparisons of different technological approaches. It deepens insights into how AI enhances creative efficiency, extends performance forms, and strengthens audience immersion in theater.

At the theoretical level, this multidimensional classification framework not only addresses the limitations of existing research, which often focuses on single themes and lacks cross-comparative analysis, but also enables researchers to better explore the compatibility of technology and art in complex narrative structures or multicultural contexts. The findings indicate that while AI technologies significantly enhance script creation efficiency and stage expressiveness, they still face challenges in emotional expression, cross-technology integration, and the safeguarding of artistic value. These challenges are particularly pronounced in areas such as multimodal emotional modelling and the use of heterogeneous cultural corpora, where tensions between technical feasibility and artistic demands become more evident. This study systematically examines these issues, providing a new theoretical perspective for the deeper integration of AI-driven theater.

At the practical level, this study distilled several key insights from successful case studies. First, technological adaptability was confirmed as a prerequisite for success. Effectively aligning the functional features of AI with the needs of theatrical creation can enhance efficiency while maintaining artistic quality. Second, interdisciplinary collaboration is essential. Deep communication and cooperation between technology developers and artists foster the emergence of innovative stage forms. Finally, the use of real-time audience feedback can enhance

interaction and emotional connection during performances, though it also introduces new challenges related to privacy and security. Balancing immediate feedback with artistic coherence remains a critical consideration.

Notably, the study also identified prevalent challenges within the field, including the complexity of technological integration, the severity of ethical and cultural adaptability issues, and the absence of evaluation frameworks. Compared to existing research, this study provides a more comprehensive synthesis of these issues and proposes potential directions for future exploration. It offers empirical insights for bridging the gap between artistic practice and industrial application in AI-driven theater.

In summary, this study holds unique value in both theoretical and practical dimensions. Theoretically, it provides a multidimensional analytical framework, expanding the depth of understanding regarding the integration of artificial intelligence and theater. Practically, through case analysis and the synthesis of key insights, it offers actionable strategies for practitioners in areas such as technology selection, team composition, and audience feedback mechanisms. Building on these contributions, future research should move beyond isolated technological breakthroughs to focus on cross-technology integration and diverse artistic demands. Efforts should also prioritize the development of ethical standards and evaluation systems, establishing a more robust foundation for the sustained innovation of artificial intelligence in the theater domain.

Limitation: Our systematic review reveals several key limitations in the current state of research on AI-driven theater. First, existing studies lack a unified framework or standards for integrating diverse technologies, such as language generation, motion capture, and augmented/virtual reality (AR/VR), resulting in fragmented approaches and challenges in real-time collaboration and resource management. Second, AI models used in theater applications are predominantly trained on Western corpora, limiting their adaptability to non-Western, multilingual, or culturally diverse contexts. This linguistic and cultural bias raises concerns about the inclusivity and representational fairness of AI-generated narratives and performances. Third, evaluation methods for AI-generated artistic expression and audience engagement rely heavily on subjective case studies, expert opinions, and qualitative assessments. The absence of standardized, quantitative metrics makes it difficult to measure artistic impact, audience reception, and the effectiveness of AI-driven storytelling in a consistent manner. Finally, our literature search was restricted to four major academic databases (Scopus, Web of Science, IEEE Xplore, and JSTOR), which, while comprehensive, may have excluded relevant studies published in non-indexed journals, industry reports, or grey literature. This limitation may affect the generalizability of our findings and underscores the need for broader data sources in future research.

Future Research Directions: The limited scope of our literature review highlights the need for broader searches across additional academic and industry databases. Future systematic reviews should include sources beyond Scopus, Web of Science, IEEE Xplore, and JSTOR—

such as ACM Digital Library, arXiv, ProQuest, and theater-specific archives—to ensure a more comprehensive representation of existing research. This would improve the robustness and generalizability of findings in the field of AI-driven theater.

Second, future studies should work on developing universal interfaces and standards for integrating diverse technological approaches (e.g., language generation, motion capture, and AR/VR) to enhance real-time collaboration and resource management. This would enhance real-time collaboration, improve resource management, and facilitate seamless interactions between AI-driven components in theatrical productions.

Furthermore, given the dominance of Western-trained AI models, future research should prioritize developing diverse, multilingual corpora that better represent non-Western and multicultural theatrical traditions. Additionally, optimizing cross-linguistic algorithms and incorporating cultural nuances in AI-generated narratives could improve inclusivity and representation in AI-assisted theater.

Finally, there is a need to develop multi-dimensional evaluation tools that incorporate objective, quantitative measures of artistic quality and audience engagement. fostering interdisciplinary collaboration through targeted initiatives, such as cross-disciplinary training programs or collaborative platforms, could help bridge the gap between technical experts and theater practitioners.

Conclusion

This study systematically reviewed the current state and challenges of the AI-driven theater field, focusing on three core directions: script generation, character interaction, and audience engagement. It identified the application pathways of AI technologies in theater and highlighted their primary bottlenecks. By constructing a multidimensional classification framework spanning technology and art, the study summarized technological advancements, successful practices, and unresolved issues, providing a systematic analytical tool for the collaborative development of technology and art.

The unique contribution of this research lies in its systematic perspective, integrating the progress in this field. It not only highlights the potential of technological innovation in theatrical creation but also clarifies key directions for future research. The findings lay a solid foundation for advancing both theoretical exploration and practical application of AI in theater, while offering new perspectives and guidance for interdisciplinary collaboration.

In summary, this study provides theoretical support and practical references for the continued development of the AI-driven theater field through a comprehensive analysis and synthesis of existing literature. Future research should focus on the deep integration of technological advancements and the innovative balance of artistic value to promote the synergistic development of theatrical creation in terms of efficiency and cultural significance.

Disclosure Statements

- **Ethical approval and consent to participate:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.
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