

ILLUMINATING INNOVATION: STAGE LIGHTING IN THE AGE OF ARTIFICIAL INTELLIGENCE

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Abstract

Theatre has navigated varying degrees of evolution since antiquity as demonstrated in its adaptability to technological advancements like the introduction of electricity culminating in stage lighting. Today, an intersection of tradition and innovation, where artificial intelligence (AI) (a machine's capability to replicate intelligent human behaviour), wields an unprecedented influence. This fusion of technology and art has initiated a re-evaluation of the creative process within the theatrical domain where machine learning enhances the analysis of existing lighting designs, enabling AI to learn from historical practices while iterating on them in new and exciting ways. This synthesis can lead to novel combinations of light features - colour, intensity, distribution and movement, generating aesthetic experiences that may not have been conceived by human designers alone. Artificial intelligence has the potential to revolutionise the creative process in stage lighting, offering designers a wealth of tools that can cultivate innovative visual experiences. Algorithms capable of analysing scripts, mood boards, and thematic elements can suggest lighting schemes tailored to the emotional tone of a performance. For instance, AI-powered systems like LightPlot can create dynamic lighting designs that adapt to the actions and emotions of performers on stage. While some theatre purists decry AI's encroachment on artistic authenticity, others herald it as a partner in exploration and innovation. This paper then, examines AI's possible influence in theatre scholarship and practice to evaluate its dual role - as both a tool that enhances artistic practices and a subject of critical examination especially, in the area of stage lighting.

Key words: Theatre, Artificial Intelligence, Stage lighting, Theatre scholarship and practice

Introduction

“Stage lighting is a vital element in creating captivating performances, influencing everything from mood to audience engagement. As technology evolves, so too does the landscape of stage lighting” (Longmangroup, 2025). As an element of production, stage lighting is about the last design element experienced in theatrical production; despite this, it has continued to prove the most technologically advanced in terms of innovations. Basically, stage lighting enhances visibility in productions enabling both performers and audience to see and appreciate the performance. Stage lighting is characterized with some controllable features like intensity, distribution, colour and movement which a lighting designer can manipulate using diverse lighting equipment to achieve

functions capable of elevating the communicative, emotional, performative narrative and aesthetic values of a given performance. Functionally, it has always been an essential element of live events, shaping the atmosphere, directing focus, and elevating performances. As the lighting and theatre industry evolve, technological advancements continue to redefine what is possible in theatrical productions.

Within the last decade, the world of stage lighting has continuously re-evolved, undergoing a profound transformation, driven largely by advances in artificial intelligence seen as a machine's capability to replicate intelligent human behaviour. Artificial Intelligence (AI) technologies have begun reshaping the scenic and performative aspects of theatrical productions, enhancing the capabilities of lighting designers and pushing the boundaries of creativity. Artificial intelligence and AI lighting models are seen to be reshaping how dramatists think about light in performances. "Light is no longer treated only as a physical or visual entity but as a data-rich medium that can be analyzed and adapted through AI systems. With the integration of sensors, learning algorithms, and data-driven systems, illumination becomes a computational process informed by intelligence models" (Karaagac, 2025).

Employing observational and literary techniques, this paper explores the prospects of stage illumination in connection with AI innovations, examining how these technologies could influence artistic expression, enhance performance values, and challenge traditional lighting design principles.

The Historical Context of Stage Lighting

Stage lighting has its roots in the ancient theatre, where natural light and rudimentary oil lamps served as the primary sources of illumination (Wilson, 1991). As theatrical practices evolved, so too did the techniques used to create distinctive effects and visual storytelling. Innovations in the 19th and 20th centuries, such as the introduction of electric lighting and the development of dimmers, colour filters and lamps, revolutionised stage lighting to a more realistic element, and often plastic artistry in functionality.

The emergence of computer-controlled lighting systems in the late 20th century gives opportunity for more dynamic and intricate lighting designs (Gillette & Dionne, 2020) where lighting cues can be stored and operated using automated control systems. Recent innovations in lighting materials

have considered energy consumption and heat emissions and further propelled the invention of light-emitting diodes otherwise called LED lamps. Marslite's (2024) article, "Exploring the Latest Trends in Stage Lighting Technology" affirms this more clearly. According to him,

In recent years, LED lighting has emerged as a game-changer in the world of stage lighting. LED fixtures offer a host of benefits, including energy efficiency, long lifespans, and vibrant color options. The versatility of LED technology has enabled lighting designers to create mesmerizing visual effects and dynamic lighting scenes that were once unimaginable. With the ability to produce a wide spectrum of colors and seamlessly transition between them, LED fixtures have become indispensable tools for creating immersive stage environments.

Marslite further observes that the "advancements in automated lighting have seen improvements in speed, precision, and reliability, allowing for seamless integration into complex lighting designs". These innovations and practice arguably, have paved the way for the integration of AI technologies in the science, technology and art of stage lighting.

Traditional stage lighting in theatrical performance.

Stage lighting has impacted invaluable on theatrical performances over the years. Lighting designers have painstakingly analysed their production scripts making sure they identify the lighting requirements for any production involved. This exercise, no doubt, has yielded design dividends in the final production outlook coming from lighting cues, light plots, and lighting production in general, hence, enabling an appealing and more communicative performative narrative. The entire lighting process has been the prerogative duty of the lighting designer and his collaborators who work diligently and collaboratively with other design staff members taking instructions from the artistic director to ensure design unity in the production.

Over the years, the lighting designer's ingenuity has assisted directors not just in illuminating productions, but in enhancing the background, emotional and incidental relevance of a given production using lighting. An instance of this is the realization of a realistic locale and projection of the ring-clouded sun motif in the 2023 production of Zulu Sofola's *King Emene* in Ambrose Alli University Arts Theatre, Ekpoma. In this production, the audience were not only convinced of the rejection of King Emene by being chased out of the shrine by a big snake, the sudden appearance of the clouded sun in the sky further accentuates his rejection (Nwanaju, 2025).

In such productions, the lighting designer not only designs the light, he also executes the lighting. With his cue sheet and lighting plot well prepared and executed, he sits attentively in the lighting booth to light the production while his collaborators are on standby for adjustments or quick repairs as the need arises. Often, the gel could be changed, burnt lamp(s) could be replaced, follow spot could be controlled among other needs to ensure a smooth and unobtrusive run of the production. In situations where cues are prepared and stored, they also required the control of the lighting designer to execute properly.

In recent times, stage lighting according to Liang Steven (2025) “is no longer just about illuminating the stage - it’s about creating immersive experiences, pushing the boundaries of visual storytelling, and engaging the audience in new, interactive ways”. This is a redefinition that seems to have engineered the innovation of artificial intelligence influencing not just the face of lighting but also the job of the lighting designer.

AI in stage lighting design

Elgammal and Mazzone (2020) explored the evolution of artificial intelligence and how it was employed by Harold Cohen in his art-making programme AARON, which produced drawings that followed a set of rules. They opined in their article, “Artists, Artificial Intelligence and Machine-based Creativity in Playform” that

AI has evolved over the past couple of decades to incorporate machine learning technology.... In contrast to traditional algorithmic art in which the artist had to write detailed code that specified the rules for the desired aesthetics beforehand, now algorithms are set up by an artist to “learn” aesthetics by looking at many images using machine learning. The algorithm only then generates new images that follow the aesthetics it has learned. The most widely used tool in this class is Generative Adversarial Networks (GANs), introduced by Goodfellow in 2014 (Goodfellow 2014), which have been successful in many applications in the AI community. It is the development of GANs that has sparked this new wave of AI art.

According to Zhen Ren in his paper, “The role of AI in theatre: Exploring the creation of AI generated stage plays”,

The advent of Artificial Intelligence (AI) has marked a transformative era across various industries, significantly impacting the creative fields, including the performing arts. In the domain of stage play production, the role of AI has evolved from a mere technological novelty to a substantive creative force (2024).

AI has rapidly permeated various domains of the entertainment industry, not limited to the theatre, concerts, and live events. The core function of AI in stage lighting revolves around data analysis, pattern recognition, and the automation of complex lighting cues and parameters. By harnessing AI algorithms, lighting designers can create immersive experiences that respond dynamically to performers and audience interactions. Ultimately, “digital technologies have expanded the possibilities of storytelling through light. Interactive light installations, virtual reality experiences, and projection mapping enable artists to craft dynamic, multidimensional narratives that engage the audience on a sensory and intellectual level (Serialioglu, 2024).

Stage Lighting in the era of Artificial Intelligence

With AI, stage lighting has seemingly continued to sit as a meeting point, blending technology and art. Innovations in stage lighting especially in lamps and controls have advanced stage lighting art to the point of smart and automated realizations thereby making the jobs of lighting designers tilt more to the area of skill than labour. AI has become an enabling tool for the creation and execution of lighting tasks without the usual cables running through the theatre spaces but with equipment remotely controlled or programmed for self-smart-control. On this backdrop, Longmangroup (2025) x-rayed the impact of AI on stage lighting, highlighting advancements and prospects and submits that

Artificial Intelligence (AI) is poised to transform the way stage lighting is managed. AI algorithms can assist in creating the perfect lighting design based on performance parameters, audience mood, and even the movement of the performers. Automation can also streamline the setup and operation of **LED stage lights**, making the process faster and more efficient. With AI-driven lighting systems, lighting designers can focus more on creative aspects while leaving the technical adjustments to AI systems.

In this regard, stage lighting in the era of AI is proving more innovative and will be explored under sub-headings viz:

1. Automated Lighting Systems

One of the most significant trends in stage lighting is the rise of smart and automated lighting systems which enhance multi-task applications in productions. In stage lighting, automated lighting systems refer to the use of intelligent lighting fixtures instead of the regular equipment that are manually controlled. These automated lighting systems can be programmed and controlled automatically to create dynamic lighting effects for performances. Automated lighting systems are classified under such key aspects as types, controls, programming, benefits, application.

Advanced DMX controllers, wireless integration, and AI-driven automation are enabling lighting designers to have a more precise control over every aspect of lighting rig. Fixtures are equipped with built-in sensors to adapt dynamically to the needs of on-going production, respond to sound cues, actors' movements, and audience engagement in real-time. Creating complex lighting sequences that would typically require extensive programming and connections have now been simplified by AI-powered lighting systems. These systems are designed to analyse rhythm of a production, make adjustments to intensity, colour, and motion, as well as create an immersive experience in real-time without recourse to manual intervention. Citing instances with automobile real-time data processing to aid a driver's smooth driving as AI induced, Hindlia and Leekha (2020) posit that "smart lighting are enabled to work with self-sufficiency with many technology involved to make lighting system work better ... [with built-in] capabilities to operate from switching on to changing colour on certain situations...". This automatically eradicates the practice of placing and changing gels or gobos on shutters including labourous walk through the ridge to adjust or focus lanterns.

The key aspects of automatic lighting system:

1. Types of Automated Lights: Automated lighting systems are classified to types based on their mobility treats. These include Moving Head Fixtures comprising lights that can tilt, pan, and change focus allowing for a variety of effects and coverage. The second are LED Fixtures which are energy-efficient lights. They can produce a wide spectrum of interchangeable colors and often have built-in control capabilities. The third type, Automated Follow Spots, are made such that they

can track performers on stage automatically, adjusting their light direction without manual intervention or human control.

2. Control Systems: This has to do with the manipulation or functional intervention or control of the equipment. It includes the DMX (Digital Multiplex) which is a standard protocol for controlling lighting fixtures and effects. It allows for the integration of various types of lighting equipment. The other is Lighting Consoles referred to devices that enable lighting operators to program and control complex lighting cues and effects, often featuring touch screens and software integrations for ease of use.

3. Programming and Automation are processes bothering on producing, arranging and computerizing or arranging on robotics lighting cues to be used in a production. This is on pre-programming and real-time control packs.

Pre-Programming: Often, lighting designers, for convenience, can create specific effects and cues in advance, which can be triggered during a performance. Such effects are generated or programmed and stored in such formats that that will be replayed on demand.

Real-Time Control: Some systems allow for live adjustments during performances, responding to the performers' movements or the music tempo. This implies that instantaneous modification(s) on programmed cues are made automatically during productions to suit the needs of prevailing situation without the designer having an impact on the equipment.

Coming from technological developments and practice of stage lighting, Automated lighting systems are obvious advancements from manually controlled traditional lighting techniques and have positioned as a cornerstone of modern stage lighting; offering designers respite. These systems incorporate AI algorithms for improved responsiveness and adaptability as it softly interacts with the environment, collects information, and seamlessly adapts to changing conditions. As observed by Karaagac (2025), “in this expanded view, light is no longer merely an instrument of visibility or atmosphere; it is an active agent that shapes spatial experience” translating into quantifiable patterns, what human perception feels intuitively. With AI, light functions as a spatial descriptor that algorithms can analyze and model effectively.

Examples of AI Tools commonly used in lighting design include:

MA Lighting GrandMA2 Lighting Console



GrandMA2 Lighting Console - Full Size

GrandMA2 Lighting Console is made almost in the shape of regular lighting console, the grandMA2 full-size represents MA Lighting's most powerful console. It offers the control of conventional light, moving lights, LED fixtures and media from one platform. It is Equipped with the most up-to-date technology with some special features like keyboard drawer and multi-touch command screen serving as input devices making the grandMA2 suitable for all lighting segments. Developed to provide an intuitive and fast control of all connected fixtures and channels, the grandMA2 fader wing provides up to 60 extra motorized executor faders for an almost unlimited number of pages giving the device extended service possibilities.

The grandMA2 has the possibility of converting and accommodating the upgrade of grandMA series 1-showfiles. To ensure an easier operation, all command keys on this device can be found in the same place on every console of the grandMA2 series. The grandMA2 offers extremely flexible and comfortable ways of programming, including nearly infinite numbers of presets, cues, pages, sequences and effects that make lighting design and operation graceful.

The grandMA2 is equipped with some unique Features which include:

- Real-time control for up to 65,536 parameters per session in connection with MA NPU (equivalent to 256 DMX universes)
- 6 DMX outputs
- 3 internal TFT wide mode touchscreens (15.4" WXGA)

- 2 external TFT screens can be connected (UXGA, touchscreens accepted)
- 1 internal command screen – multi-touch (9" SVGA)
- 30 motorized executor faders
- Integrated keyboard drawer
- Built-in uninterruptible power supply (UPS)
- 2 etherCON connectors, 5 USB 2.0 connectors
- Motorized monitor wing
- 2 motorized A/B fader 100mm
- Individually backlit and dimmable silent (clickless) keys

(<http://shop.solotech.com/products/ma-lighting-grandma2-lighting-console-full-size>),

LightPlot



Lightplot is a machine learning system often associated with data visualization and analytics. It can be used for specific and common applications in the course of light plotting which include:

1. **Interactive Data Visualization:** Lightplot allows users to create interactive plots that can be manipulated in real-time, which in the course of production, helps visualize complex datasets more effectively.
2. **Multiple Plot Types:** With lightplot, Users can generate various types of plots, such as line graphs, bar charts, scatter plots, and heatmaps.
3. **Customizable Options:** Users can customize axes, labels, legends, and colors to enhance the clarity and visual appeal of their plots.
4. **Real-time Data Integration:** Some versions may support real-time data feeds, enabling dynamic visualization that updates as new data comes in.
5. **User-friendly Interface:** Intuitive design makes it accessible for users without extensive programming or data analysis background.
6. **Export Capabilities:** Users can often export their visualizations in various formats (like PNG, JPEG, PDF) for sharing or presentation purposes.

<https://petapixel.com/2012/05/09/lightplot-a-robotic-arm-that-creates-animated-light-paintings/>

ChamSys MagicQ is another algorithm powered by AI for lighting control. They allow lighting designers to automate complex lighting sequences that would be virtually impossible to execute manually during a live performance. The integration of AI in lighting control systems facilitates real-time decision-making based on audience reactions, performer movements, and environmental factors. To achieve this, software algorithms are used to analyse and make predictions based on data.

2. Real-time Analytics and Feedback Mechanisms

In the time past, theatre administrators would rely on results generated from post-production audience analysis to arrive at audience take-aways from a given production (Malomo, 2002). Today, machine algorithms which are AI-driven analytic tools, offer invaluable insights into audience behaviours. These systems can track how lighting affects audience engagement and emotional responses during performances. By analysing this data, AI can recommend adjustments to lighting in real-time, allowing for a more immersive experience. For instance, during a dramatic

scene, the lighting can shift to more subdued tones based on sensed audience reactions, thus heightening the emotional impact. To achieve this effect, Hindolia and Leekha (2020) aver that “it takes three things to actively use artificial intelligence to control something: information, self-learning software, and the capability of technology to act and react” and above all, to make the best out of these algorithms, they should be given “the capability to device possible technology in a more consistent and cost-effective way than the predetermined human rule”.

3. Virtual Reality and Augmented Reality Integration

Virtual reality (VR) and augmented reality (AR) are increasingly finding their place in stage lighting design. Tools like TouchDesigner (<https://www.youtube.com/watch?v=Y0xZzuYS2YI>) and Unreal Engine (<https://www.unrealengine.com/en-US>) leverage AI to create immersive environments where lighting is responsive to both the narrative and the audience. This symbiotic relationship between AI, VR, and stage lighting not only amplifies the visual narrative but also encourages innovative storytelling methods that blur the lines between reality and performance.

4. Machine Learning and Predictive Lighting Design

Machine learning is revolutionising the way lighting designers approach their craft. Algorithms can analyse vast amounts of historical data related to lighting patterns and audience engagement, enabling predictive modelling for future productions. For example, an AI tool like Unreal Engine (<https://www.unrealengine.com/en-US>) might learn that certain lighting transitions evoke stronger emotional responses in audiences during specific types of scenes. This data-driven approach can aid designers in making informed decisions that enhance storytelling while minimising trial and error.

5. Collaborative Tools and Enhanced Creativity

AI-driven collaborative tools, such as the lighting design software Lightwright (<https://theatre crafts.com/bhc/equipment/john-mckernon-lightwright>) and Vectorworks (<https://www.vectorworks.net/en-US>), enable lighting designers to work in tandem with other production team members seamlessly. These tools incorporate AI functionalities that assist in drafting complex lighting plots and accommodating changes made in real time. This collaborative

aspect not only streamlines the production process but also fosters a creative environment where ideas can flow freely without the constraints of traditional design methodologies.

Merits of AI in stage lighting

From the on-going, it would be deduced that the integration of AI tools in stage lighting offers numerous benefits that extend beyond mere convenience. These benefits are highlighted as follow:

Data-Driven Decision Making

AI enables lighting designers to make informed decisions based on empirical data rather than intuition or speculation. This allows for a more strategic approach to lighting design, resulting in more impactful performances. The use of data analysis in stage lighting enhances potential for predictive analysis. AI systems can analyse vast amounts of data from past performances, identifying patterns and preferences that inform future lighting designs. AI tools can assist in real-time adjustments to lighting setups, accommodating variations in timing, mood, and even audience reactions. This adaptability allows for a more fluid, intuitive approach to lighting design thereby elevating the overall production quality.

Enhancing artistic expression

As lighting designers collaborate with AI technologies, they face exciting opportunities to engage in creative exploration. The traditional role of the designer is being transformed from a static interpreter of the script and performance to an interactive partner with AI. By leveraging machine learning algorithms, designers can experiment with an array of variables, creating unique visual motifs that enhance the narrative and emotional depth of the performance since AI is a tool used to enhance designer's job (Negrini, 2024). In the article, "Curtain call for AI: Transforming theatre through technology", Horváth (2025) admits an increased application of AI in different aspects of the theatre thereby enhancing the collaborative project "A.I. Theatre: Artists and Machines" which illustrates how AI can assist in the conceptualisation of a lighting design as noted by Negrini (2024). In this initiative, AI-generated visual prompts guide lighting designers in creating distinctive environments that align with the performance's themes. These tools offer an innovative way to brainstorm ideas and push the limits of conventional lighting applications.

Moreover, AI-powered systems allow for the creation of adaptive lighting that evolves throughout the performance. This approach is instrumental in productions that heavily rely on interactivity, where the lighting must respond to live action while contributing to the overall atmosphere. The fusion of human creativity with AI's computational power enriches the artistic possibilities of stage lighting.

Automating Complex Tasks

With the rapid evolution of AI technologies, the automation of complex tasks within stage lighting has become increasingly feasible. This has tremendous implications for the logistics of production, enabling crews to save time and reduce the likelihood of human error. Through the implementation of AI-driven lighting control systems, designers can programme intricate lighting effects with remarkable precision.

For example, the use of AI in controlling moving lights and fixtures has revolutionised the way designers execute cues. AI-enabled lighting consoles can track and adjust the positions of lights in real time, simplifying the rigging process and increasing the efficiency of rehearsals. This allows lighting teams to focus on creative decisions rather than getting bogged down by technical challenges. This further helps to manage time as the automation of these tasks is not only time-saving but also enhances the overall quality of the production.

The Future of AI in Stage Lighting

While the marriage of AI and stage lighting heralds exciting advancements, it also raises important questions and challenges. One prominent concern is the potential for job displacement in the theatre industry. As AI systems become more capable of undertaking tasks traditionally performed by humans, especially lighting designers, there is a fear that the demand for certain skilled lighting technicians may decline. However, “experts argue that rather than replacing human creativity, AI serves as an augmentation tool” (Negrini, 2024). The collaboration between AI and human designers can allow for greater focus on innovative aspects of lighting design, facilitating a rekindling of artistic roles rather than eradicating them.

As the entertainment industry continues to push boundaries through technological integration, the future of AI in stage lighting appears promising. With continual advancements in machine learning

and data analytics, it is likely that AI systems will become even more sophisticated, enabling further real-time adjustments, increased interactivity, and deeper integration into the creative process.

In anticipation of this future, it is crucial for lighting designers to engage with AI technologies while understanding both their potential and limitations. Emphasising collaboration between human artists and AI systems can foster a rich environment for exploration and innovation, resulting in productions that resonate with audiences on multiple levels.

Moving forward, with the innovations in AI/stage lighting synergy, education and training in AI applications for theatrical lighting will become a vital aspect of academic programs in theatre design possibly fashioning a research anchorage. This is on the premise that as the techniques and tools evolve, so too should the skill sets of new generations of lighting designers. By equipping them with the knowledge to leverage AI innovations responsibly and creatively, the industry can continue to thrive in an era defined by rapid technological change.

Conclusion

Artificial Intelligence (AI) have been presented in this paper as a grand innovation in the consistent re-involvement of stage lighting. This synergic involvement of AI and lighting as explored has further moved lighting from its basic function of illumination to immersive audience consideration, involvement and participation in theatrical production which invariably may lead to greater audience patronage.

There may seem to be increased pleasure in the job of the lighting designer. But the involvement of AI would obviously demand a more skillful designer who must be awake to the demands of the time. He must keep evolving as his profession evolves since there is no better time to synchronize with other design staff than now through a skillful and not careful use of AI.

There is no doubt saying that these innovations would further beam light of economic gains to the theatre practice. With many companies producing for the theatre, attention no doubt will be attracted with accompanying sponsorships. In other words, innovating illumination: AI has gainfully improved the science, technology and art of stage lighting.

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