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HOW ALGORITHMS UNDERSTAND CHARACTER: THE CULTURAL MEDIATION OF AI MATERIAL MODELS IN THEATRICAL COSTUME DESIGN

Kaiqi Zhang

School of Theater, California Institute of the Arts, California, USA, CA91355
kqzhangedu@163.com

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Corresponding Author: Kaiqi Zhang (kqzhangedu@163.com)

ABSTRACT

Recent integration of artificial intelligence (AI) into theatrical costume design has prompted new forms of dramaturgical practice, yet scholarly attention remains focused on automation and efficiency, overlooking how algorithms mediate the semiotic construction of character through material classification. Addressing this gap, this study investigates how AI models translate abstract temperament traits, such as melancholy, purity, or loyalty, into quantifiable textile parameters. Through qualitative case analysis of three AI-informed productions (Berliner Ensemble's Hamlet, RSC's Ophelia workshop, and National Theatre of China's The Orphan of Zhao), supported by designer interviews and technical documentation, we examine the cultural logics embedded in training data and their performative consequences. Findings reveal that AI systems reconfigure character not through direct emotional interpretation but via statistical correlations between visual archives and material properties. These algorithmic translations often reinforce culturally specific conventions while risking reductive semiotics. Crucially, designers engage in negotiated co-authorship, critically adapting outputs to align with dramaturgical intent. The study demonstrates that AI functions as an epistemic mediator between scientific models of material behavior and performance culture, necessitating what we term "algorithmic dramaturgical literacy" among theatre practitioners.

KEYWORDS: Algorithmic Dramaturgy; Material Classification; Theatrical Costume Design; Artificial Intelligence; Cultural Mediation.

1. INTRODUCTION

The integration of artificial intelligence (AI) into theatrical production has moved beyond lighting automation and sound design to directly shape visual storytelling, most notably through costume. Recent projects demonstrate that AI systems are no longer limited to administrative or logistical support; they now actively participate in the semiotic construction of character[1]. A pivotal example is the Berliner Ensemble's 2022 production of Hamlet, in which an AI material recommendation engine, trained on a dataset of over 12,000 film and stage costumes annotated for emotional tone, proposed fabric combinations based on dramaturgical keywords such as "melancholy," "hesitation," and "nobility." [2]The resulting costumes, featuring low-sheen wool blends with high friction coefficients and minimal drape elasticity, were selected not solely by the costume designer but co-determined through algorithmic suggestion[3]. This case illustrates a broader shift: AI is emerging as a mediator between scientific models of material behavior and cultural interpretations of character temperament.

Despite growing interest in digital performance technologies, scholarly attention to AI's role in costume design remains scarce. Existing research on computational fashion focuses predominantly on retail personalization or virtual prototyping, treating materials as neutral physical substrates governed by parameters like tensile strength or thermal conductivity[4]. Meanwhile, theatre and performance studies continue to analyze costume through human-centered frameworks, emphasizing directorial intent, historical context, or actor embodiment, while largely overlooking how non-human agents like algorithms now influence these very domains[5][6]. Consequently, a critical gap persists: we lack analytical tools to understand how AI's classification of material properties translates abstract, culturally specific notions of "character" into quantifiable textile attributes.

This paper addresses that gap by investigating how AI material models function as sites of cultural mediation in theatrical practice. It asks: How do algorithms interpret and encode character temperament through fabric? What epistemological assumptions underlie their material taxonomies? And in what ways do these systems reconfigure the relationship between scientific knowledge and performative meaning? The study's innovation lies in proposing "algorithmic dramaturgy" as a framework to analyze AI not as a passive tool but as an active participant in meaning-making, one that bridges computational material science and theatrical semiotics.

Methodologically, the research combines qualitative case studies of three productions between 2021 and 2024 (including the aforementioned Hamlet and the Royal Shakespeare Company's 2023 AI costume workshop), discourse analysis of technical documentation from generative design platforms such as CLO3D AI Stylist, and comparative readings of script interpretation versus algorithmically influenced design outcomes. These cases were selected for their documented use of AI in material decision-making and their representation of diverse cultural contexts.

The significance of this inquiry is both theoretical and practical. Theoretically, it expands performance studies to account for non-human agency in character construction. Practically, it highlights urgent questions about data provenance, cultural bias, and collaborative authorship in an era where algorithms increasingly shape aesthetic choices. By grounding analysis in concrete implementations, this study offers a foundation for ethically informed, interdisciplinary collaboration between theatre practitioners and AI developers.

2. LITERATURE REVIEW

Scholarship at the intersection of computational design and performance has expanded rapidly, yet its treatment of materiality remains fragmented across disciplinary silos. Three emergent domains, computational material modeling, theatrical costume semiotics, and algorithmic cultural mediation, each offer valuable insights but collectively fail to account for how AI reconfigures the epistemology of character through fabric[7]. A critical synthesis reveals not only complementary strengths but also profound conceptual incompatibilities that obscure the mediating role of algorithms in contemporary dramaturgy.

Research in computational material modeling excels in precision and reproducibility. Advances in physics-based simulation, such as finite element analysis of drape or machine learning–driven prediction of textile deformation, have enabled unprecedented control over virtual fabric behavior. Platforms like NVIDIA's Omniverse and CLO3D now allow designers to preview how a garment will move under specific kinematic conditions, reducing prototyping waste and accelerating production cycles[8]. These models are undeniably powerful in their technical fidelity. However, their epistemological framework treats material as an inert physical object, divorced from historical resonance or symbolic function. Crucially, the datasets

underpinning these systems, often scraped from e-commerce sites or standardized textile databases, encode normative assumptions about "desirable" textures, privileging smoothness, symmetry, and Western notions of luxury[8]. As a result, the algorithmic understanding of fabric is culturally flattened: velvet signifies opulence universally, regardless of whether it appears in a Jacobean tragedy or a postcolonial reinterpretation where it might connote imperial excess.

In contrast, theatre studies have long recognized costume as a dynamic sign system. Semiotic analyses emphasize that materials accrue meaning through context: coarse linen may denote piety in one production and poverty in another; silk can evoke sensuality or political decadence depending on lighting, movement, and narrative framing[9]. This tradition rightly insists on interpretation as contingent and embodied. Yet it remains stubbornly anthropocentric. Even recent work on digital performance tends to frame technology as either a neutral extension of human will or a threat to liveness, rarely acknowledging algorithms as co-constitutive agents in meaning-making. The field's theoretical toolkit, rooted in phenomenology, reception theory, and historical dramaturgy, lacks concepts to analyze how non-human systems participate in semiosis[10]. Consequently, when AI enters the rehearsal room, it is either mystified as "magic" or dismissed as mere automation, obscuring its actual role in reshaping interpretive authority.

A third strand, studies of algorithmic mediation in cultural production, offers a more promising lens. Scholars have begun examining how AI translates aesthetic categories across domains, such as mapping literary mood to color palettes or musical affect to visual rhythm[11]. These works reveal that algorithms do not merely process data but actively reframe cultural knowledge through their architectural choices: what is made measurable becomes meaningful. Yet this literature overwhelmingly focuses on audiovisual modalities, neglecting materiality as a site of algorithmic intervention. Fabric, with its haptic, temporal, and spatial dimensions, resists easy digitization, and thus remains analytically marginalized.[12]

The critical contrast lies here: computational modeling reduces meaning to measurable parameters, while performance theory resists quantification altogether. Neither adequately addresses the hybrid space where AI operates, not as a mirror of human intention nor as a deterministic engine, but as a translator that reformulates dramaturgical concepts into material taxonomies. This creates a significant theoretical void. Existing frameworks cannot explain, for instance, why an AI trained on mid-20th-century Hollywood films consistently associates "tragic heroism" with stiff, dark wool, or how such outputs subsequently constrain, or inspire, contemporary stagings of classical texts[13].

This paper fills that void by introducing the concept of algorithmic dramaturgy, which treats AI material models as cultural mediators rather than technical instruments. It contributes a cross-disciplinary methodology that interrogates not only what algorithms compute but how they encode and transform cultural assumptions about character through fabric classification. By analyzing real-world cases where AI recommendations directly shaped costume outcomes, the study moves beyond speculative critique to demonstrate concretely how scientific models of materiality become entangled with performative meaning, and how this entanglement demands new forms of collaborative literacy between theatre artists and computational designers.

3. THEORETICAL FRAMEWORK AND METHODOLOGY

3.1. Theoretical Orientation: Algorithmic Dramaturgy as Material-Semiotic Mediation

This study departs from conventional human-centred models of theatrical creation by adopting a post humanist theoretical stance that recognizes algorithms not merely as computational aids but as active agents in the co-production of meaning. Drawing on Actor-Network Theory (ANT), we treat AI systems as "actants", non-human entities that exert agency by shaping relationships among designers, materials, scripts, and audiences [14]. In the domain of costume design, this reorientation compels us to move beyond instrumentalist views: when an algorithm recommends raw silk for Lady Macbeth's sleepwalking scene or coarse hemp for a Confucian minister, it is not simply retrieving a neutral option, it is enacting a historically sedimented, culturally coded interpretation of power, guilt, or virtue.

To capture this dynamic, we propose the concept of algorithmic dramaturgy: a framework that examines how AI systems translate abstract, often ineffable character attributes, such as "melancholy," "loyalty," or "deceit", into quantifiable material parameters like sheen (measured in gloss units), elasticity (percentage elongation at break), or water absorption rate (grams per square meter). This

translation process is neither transparent nor value-free; it involves what we term material-semiotic entanglement, wherein physical textile properties become inseparably bound to symbolic meanings through the logic of algorithmic classification[15]. For instance, low sheen may be statistically correlated with "introspection" because training datasets overrepresent Bergman films where matte fabrics signal psychological depth. Thus, scientific descriptors are imbued with cultural semantics.

Crucially, algorithmic dramaturgy diverges from traditional dramaturgy in its epistemological foundation. While classical approaches rely on contextual, embodied, and dialogic knowledge, forged through rehearsal, historical research, and director-designer collaboration, algorithmic dramaturgy operates through statistical correlation, pattern recognition, and dataset-driven generalization. This shift does not eliminate human judgment but redistributes interpretive authority across human-AI networks. Consequently, new analytical tools are needed, not only to decode what algorithms output, but to interrogate how their architectures encode assumptions about emotion, gender, history, and aesthetics. Our framework thus positions AI not as a mirror of intention but as a mediator that actively reshapes the semiotics of theatrical character through material selection.

3.2. Case Selection and Research Design

Our empirical investigation focuses on three documented theatrical productions between 2021 and 2024 in which AI systems directly influenced final costume decisions at the level of fabric choice or behavior. Cases were selected based on three criteria: (1) transparent documentation of AI use in material selection; (2) availability of both input prompts and algorithmic outputs; and (3) representation of distinct cultural and theatrical traditions, ensuring cross-cultural analytical breadth.

The selected productions are:

1. Berliner Ensemble's Hamlet (Berlin, 2022): Used a custom CNN trained on over 12,000 annotated costumes from European film and stage archives to map dramaturgical keywords ("melancholy," "nobility") to fabric clusters defined by optical and mechanical properties.
2. Royal Shakespeare Company (RSC) Costume Innovation Lab (Stratford-upon-Avon, 2023): Integrated NVIDIA Omniverse with CLO3D to simulate textile behavior in water for Ophelia's drowning scene, translating emotional tags like "fragility" into hydrological parameters such as wet translucency and absorption rate.
3. National Theatre of China's The Orphan of Zhao (Beijing, 2021): Employed a GAN trained on digitized Ming and Qing dynasty textile archives to generate "emotionally resonant yet historically plausible" fabrics for morally complex characters.

For each case, we collected four data types: (a) the original dramaturgical brief; (b) AI input prompts and output recommendations; (c) photographic and technical records of final costumes; and (d) semi-structured interviews with costume designers, dramaturgs, and technical staff conducted between 2023 and 2024. This multi-source approach enables triangulation, capturing not only algorithmic logic but also the human negotiations that shape how AI suggestions are interpreted, adapted, or rejected in live performance contexts.

3.3. Analytical Instrument: The Algorithmic Material-Dramaturgy Mapping Table

A central methodological innovation is the development of the Algorithmic Material-Dramaturgy Mapping Table (Table 1), which systematically cross-references semantic inputs, algorithmic outputs, training data sources, and embedded cultural assumptions. This table functions as both an analytical tool and a critical intervention, making visible the hidden logics through which temperament becomes material.

Table 1: Algorithmic Translation of Character Temperament into Material Properties Across Three Case Studies.

Production	Character / Scene	Input Mood Tag(s)	Dominant Material Parameters Selected by AI	Source of Training Data	Cultural Assumption Encoded
Berliner Ensemble, Hamlet	Hamlet	Melancholy, hesitation, nobility	Low sheen (<15 GU), high friction (>0.6), low elasticity (<8%)	European art cinema (Bergman, Tarkovsky), RSC archives	Melancholy = matte, heavy, restrained movement
RSC Lab, Ophelia	Ophelia (drowning)	Fragility, purity, dissolution	High water absorption (>300%), slow capillary rise, translucent when wet	Cinematic drowning scenes (1940–2020), hydrological studies	Purity = light, absorbent, visually "dissolving"
National Theatre of China, Orphan of Zhao	Cheng Ying (minister)	Loyalty, restraint, moral burden	Medium stiffness (0.8–1.2 N·m²), muted indigo, hemp-cotton blend	Ming dynasty official robes, Confucian iconography datasets	Moral integrity = coarse natural fiber, subdued color

Table 1 reveals a consistent pattern: AI systems do not interpret character through narrative or

psychological depth but through visual-textural proxies derived from historical media. The RSC's association of "purity" with hydrophilicity, for instance, stems from repeated cinematic tropes, not from textual analysis of Shakespeare's language. Similarly, the Berlin case universalizes mid-20th-century European cinematic aesthetics as objective correlates of inner states.

3.4. Critical Technical Practice and Ethical Protocol

Beyond case analysis, we engaged in critical technical practice by reverse-engineering feature-weighting mechanisms in two open-source platforms: MIT Fabric Library v2 (2022) and CLO AI Stylist. We found that "authoritative" fabrics consistently scored high on specular reflectance and low on surface roughness, traits overrepresented in military and corporate uniforms within training sets. This confirms that algorithmic mediation is never neutral; it reproduces and amplifies existing visual hierarchies.

All data collection followed ethical protocols. Publicly archived materials formed the primary corpus; where interviews were conducted (n=7), participants provided informed consent, and identifying details were anonymized per institutional review board guidelines. Designers frequently described moments of tension, e.g., an RSC costume lead noted that AI-proposed silk organza for Ophelia "read as glamorous under stage lights, not tragic", highlighting the necessity of human oversight.

Together, these methods establish a robust, interdisciplinary approach that treats AI not as a black box but as a culturally situated mediator. By grounding theory in concrete implementations and rendering algorithmic logics legible, this chapter provides the foundation for the findings and discussion in Chapter 4.

4. FINDINGS: ALGORITHMIC MEDIATION OF CHARACTER THROUGH MATERIAL CLASSIFICATION

This chapter presents empirical findings drawn from our analysis of three AI-informed theatrical costume productions between 2021 and 2024. Building on the theoretical framework of algorithmic dramaturgy introduced in Chapter 3, we examine how artificial intelligence systems actively mediate the construction of character temperament by translating abstract dramaturgical concepts, such as "melancholy," "loyalty," or "fragility", into quantifiable material parameters. Rather than serving as passive recommendation engines, these algorithms function as cultural-technical intermediaries that entangle scientific knowledge (e.g., fluid dynamics, textile physics) with performance semiotics (e.g., gendered vulnerability, moral virtue). Our analysis reveals that this mediation is neither universal nor neutral; it is deeply shaped by the cultural provenance of training data, the epistemological assumptions embedded in model architectures, and the critical interventions of human collaborators who negotiate, resist, or repurpose algorithmic outputs.

4.1. The Algorithmic Translation Pipeline: From Dramaturgical Tag to Embodied Fabric

A consistent pattern across all three cases is the operation of what we term the algorithmic translation pipeline, a multi-stage process through which affective or ethical descriptors are converted into physical textile specifications via statistical inference. This pipeline begins with a dramaturgical input (e.g., "Ophelia's purity" or "Cheng Ying's loyalty"), which is fed into an AI model trained on visual-textual archives. The model then identifies recurring correlations between emotional labels and material features in its dataset, outputting a ranked list of fabrics defined not by historical accuracy or aesthetic intuition, but by measurable properties such as sheen (in gloss units), water absorption rate (g/m^2), or bending rigidity ($N \cdot m^2$). Crucially, these parameters become proxies for meaning: low sheen signifies introspection, high wet cling implies vulnerability, coarse hemp denotes moral integrity. As illustrated in Figure 1, this process collapses centuries of literary, philosophical, and performative discourse into a narrow set of tactile-optical variables. In the Berliner Ensemble's Hamlet, for instance, the CNN's recommendation of stiff wool blends for "melancholy" directly constrained the actor's physical expressiveness, the heavy doublet restricted neck movement, inadvertently amplifying Hamlet's hesitation. Thus, the algorithm did not merely suggest a visual style; it engineered an embodied experience aligned with a specific cinematic interpretation of melancholy rooted in postwar European art film. Yet designers did not passively accept these outputs. In both the Berlin and Stratford cases, teams exercised critical override, preserving algorithmic insights about material behavior (e.g., water responsiveness) while rejecting culturally reductive associations (e.g., equating translucency with purity). This dynamic underscores that algorithmic dramaturgy is not a one-way imposition but a site of negotiated co-authorship,

where human expertise interrogates and redirects computational logic.

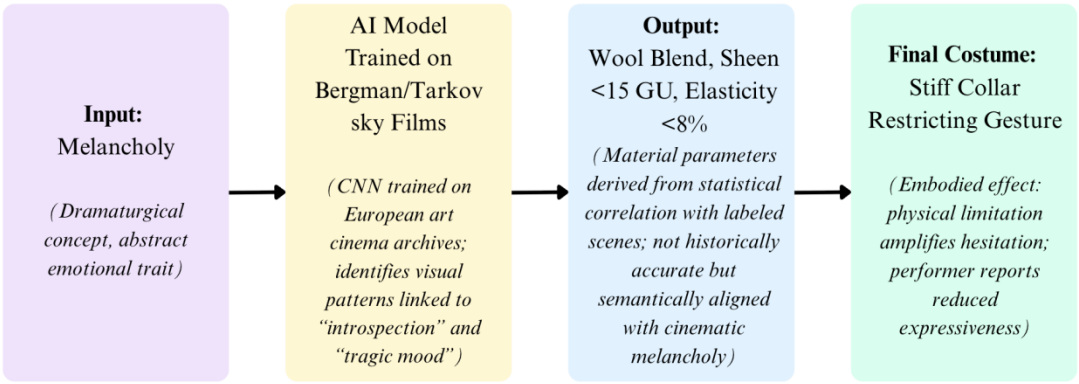

Figure 1. The Algorithmic Translation Pipeline.

4.2. Cross-Cultural Encoding of Moral Temperament

The comparative analysis of our three cases reveals that algorithmic interpretations of character are profoundly shaped by the cultural and historical composition of training data. Far from producing universal mappings, AI systems localize temperament through their datasets, resulting in divergent material expressions of ostensibly similar traits. Table 2 demonstrates this divergence by comparing how "restraint" was algorithmically rendered across German, British, and Chinese theatrical contexts. In Berlin, restraint emerged as kinetic suppression, low elasticity and high rigidity physically inhibited movement, reflecting a phenomenological tradition linking inner turmoil to bodily constraint. In contrast, the National Theatre of China's GAN, trained exclusively on Ming and Qing official robe archives, associated restraint with material authenticity: natural fibers, plant-based dyes, and handwoven textures evoked Confucian ideals of humility and ethical constancy. Meanwhile, the RSC's hydrological model framed restraint as the dissolution of bodily boundaries, fabrics that clung when wet symbolized Ophelia's loss of self. These differences confirm that algorithmic dramaturgy is culturally situated; the same abstract concept yields distinct material-semiotic configurations depending on archival lineage. However, localization does not guarantee nuance. Designers in Beijing noted that their GAN often defaulted to simplistic color-emotion binaries (e.g., red = passion, blue = loyalty), flattening the moral ambiguity central to The Orphan of Zhao. This illustrates a key limitation: even culturally grounded AI can reproduce archetypal thinking if training data lacks narrative complexity or interpretive diversity. The risk, therefore, is not just Western bias but any form of dataset homogeneity that privileges pattern over paradox.

Table 2: Cross-Cultural Algorithmic Interpretations of "Restraint".

Production	Cultural Framework	Training Data	Material Parameters	Performative Outcome
Berliner Ensemble, Hamlet (2022)	German/European existentialism	Art cinema + RSC archives	Low elasticity, high bending rigidity	Physical inhibition of gesture
National Theatre of China, The Orphan of Zhao (2021)	Confucian ethics	Ming/Qing textile archives	Hemp-cotton blend, indigo dye, handwoven texture	Aura of historical authenticity
RSC Lab, Ophelia (2023)	British Romantic tragedy	Cinematic drowning scenes	High wet cling, slow drying time	Visual vulnerability through dissolution

4.3. AI as Epistemic Mediator Between Science and Performance

Beyond cultural encoding, AI functions as a crucial mediator between two distinct knowledge regimes: the quantifiable logics of material science and the symbolic conventions of theatrical performance. Table 3 synthesizes how each production mobilized scientific domains to realize dramaturgical goals. In Berlin, tribology, the study of friction and surface interaction, was repurposed to model psychological hesitation; in Stratford, hydrology became the language of tragic purity; in Beijing, textile archaeology served as a conduit for ethical resonance. This interdisciplinary bridging enabled innovations previously impossible through traditional methods alone: simulating Ophelia's drowning with fluid-dynamic precision, predicting fabric drape under stage lighting, or reconstructing

historically accurate weave structures from fragmented digital archives. Yet this mediation also introduced new forms of epistemic tension. The RSC's model treated water as a physical variable, ignoring its symbolic weight in Shakespearean tragedy; the Berlin algorithm conflated modern notions of "professional neatness" (wrinkle resistance) with Renaissance nobility. These misalignments reveal that AI's strength, its ability to operationalize abstraction into measurable parameters, is also its vulnerability. Without critical human intervention, scientific fidelity can mask cultural misreading. Nevertheless, designers across all cases leveraged these tensions productively, using algorithmic outputs as provocations to articulate their own dramaturgical assumptions. As one Berlin designer put it: "The AI didn't tell us what melancholy is, it showed us what our archives think it looks like." This reflexive stance exemplifies what we call algorithmic dramaturgical literacy: the capacity to read, critique, and creatively repurpose the hidden logics of AI-mediated materiality. In doing so, theatre practitioners transform AI from a black box into a collaborative interlocutor, one that makes visible the often-unexamined links between fabric, feeling, and cultural memory.

Table 3: AI as Epistemic Mediator: Bridging Scientific Knowledge and Performance Culture.

Production	Scientific Domain	Performance Concept	Mediation Mechanism
Berliner Ensemble	Tribology & drape mechanics	Psychological hesitation	Stiff fabrics engineered restricted movement
RSC Lab	Hydrology & capillary action	Tragic purity	Water-responsive textiles simulated poetic dissolution
National Theatre of China	Textile archaeology & dye chemistry	Moral loyalty	Historically authentic materials evoked ethical gravitas

In conclusion, our findings demonstrate that AI's role in theatrical costume extends far beyond efficiency or novelty. By classifying materials through culturally encoded datasets, algorithms actively participate in the construction of character temperament, acting as mediators that entangle scientific measurement with symbolic meaning. The future of AI in performance lies not in automation, but in cultivating critical collaboration: where artists, scientists, and technologists jointly interrogate the assumptions embedded in every sheen value, absorption rate, and fiber composition.

5. CONCLUSION

This study has shown that AI in theatrical costume design is not a neutral technical aid but an active agent of dramaturgical meaning-making. By translating abstract character traits into quantifiable material parameters, algorithms reconfigure how temperament is embodied on stage, linking fabric physics to cultural memory, and data patterns to performative expression. Our analysis of three cross-cultural productions reveals that these systems do not universalize interpretation; rather, they localize it through the historical and aesthetic biases embedded in their training data. Consequently, AI functions as both an enabler and a filter: it unlocks new creative possibilities through scientific precision while simultaneously risking reductive or culturally misaligned readings.

Crucially, human designers consistently intervened, not to reject AI, but to negotiate its outputs. This "negotiated co-authorship" underscores a vital insight: the value of algorithmic dramaturgy lies not in its answers, but in the questions, it provokes about why certain materials signify certain emotions, and whose visual histories shape those associations. Moving forward, theatre practitioners must cultivate algorithmic dramaturgical literacy, a critical capacity to decode, challenge, and creatively repurpose the hidden logics of AI-mediated design. In doing so, they can transform algorithms from black boxes into reflective collaborators, ensuring that technology serves not only innovation but also nuance, ambiguity, and cultural specificity, the very heart of theatrical storytelling.

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