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Integration of Cognitive Intelligence and Cultural Industries: Current Status, Challenges, and Future Trajectories

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Abstract: The rapid advancement of artificial intelligence technologies has propelled cognitive intelligence (CI) into becoming a pivotal force reshaping production modes, dissemination mechanisms, and business models within the cultural industry. Grounded in the theoretical framework of cognitive intelligence, this study employs multidimensional empirical analysis to demonstrate that while significant progress has been achieved in applications spanning cultural content generation, personalized dissemination, immersive experiences, and global cultural outreach, three-dimensional challenges persist across the technological, ethical, and institutional domains. These include: (1) the misalignment between algorithmic capabilities and the essence of humanistic creation, resulting in deficient emotional expression, (2) ambiguities in rights attribution triggering copyright disputes, and (3) existing regulatory frameworks lagging behind digital cultural production paradigms. To address these constraints, this research innovatively proposes a tripartite synergistic optimization pathway encompassing cognitive, cultural, and technological dimensions. By expanding cognitive paradigms, enhancing technology-enabled empowerment, ensuring institutional adaptability, and deepening stakeholder collaboration, this approach ultimately facilitates the cultural industry's paradigm shift from efficiency-driven enhancement to humanistic value-led high-quality development. The study further emphasizes that advancing the intelligent transformation of the cultural industry necessitates strengthening technology-driven innovation, refining institutional support mechanisms, and constructing a collaborative and mutually beneficial ecosystem to realize the deep integration and sustainable innovation of cultural technologies.

Keywords: Culture-technology convergence; High-quality development; Cognitive intelligence; Cultural industry; Tripartite synergistic pathway

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1. Introduction

Amidst the vigorous expansion of the digital economy, the deep integration of cultural industries and artificial intelligence technologies is accelerating the restructuring of social innovation ecosystems [1]. As an advanced

paradigm in AI evolution, Cognitive Intelligence (CI) — leveraging its groundbreaking advancements in natural language processing, knowledge graph reasoning, affective computing, and generative creation — provides revolutionary technological underpinnings for cultural sectors [2]. At present, cognitive intelligence is experiencing rapid development. Cognitive computing and business intelligence have already found extensive applications in accounting, finance, and management. This phenomenon suggests that these "cognitive intelligence" technologies, including large language models such as ChatGPT, are being swiftly adopted by these core business functions and are rapidly infiltrating traditional yet critical business domains [3].

With the commercialization of large-model platforms such as ChatGPT, ERNIE Bot, Sora, and Midjourney, cultural industries are undergoing an intelligent transformation centered on Generative Artificial Intelligence (GenAI). By simulating higher-order human cognitive mechanisms, CI technologies are redefining production paradigms, creative boundaries, and dissemination pathways for cultural content—a shift of strategic significance for an industrial ecosystem whose core mission resides in cultural creation and value transmission [4–5].

Nevertheless, the current integration faces three-dimensional challenges, as systematically illustrated in **Figure 1**.

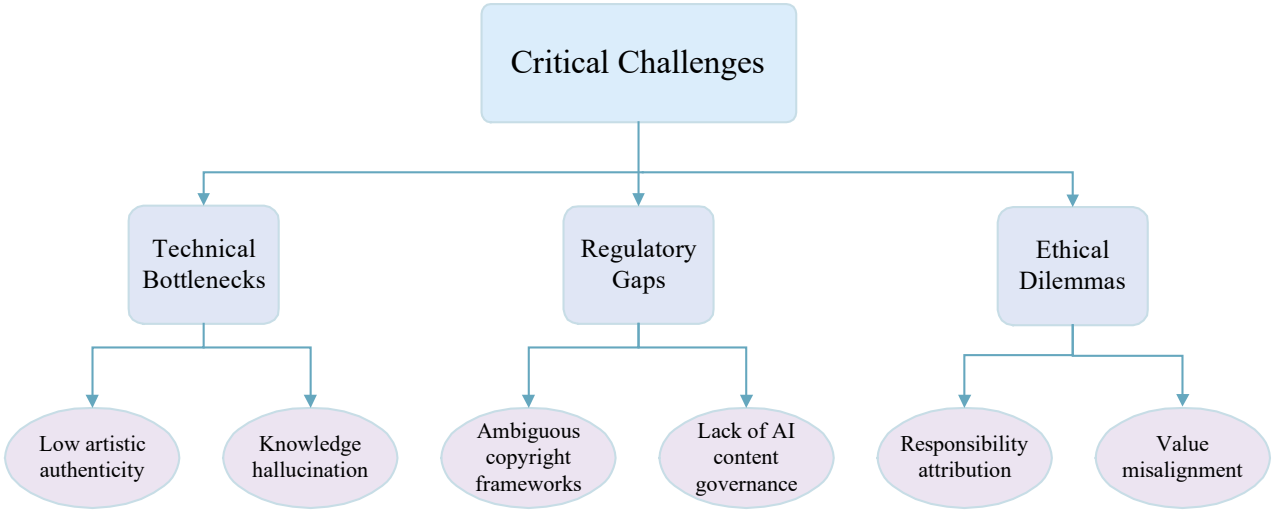

Figure 1. Schematic overview of the challenges confronted

1.1. Technical bottlenecks

The core challenge originates from a fundamental misalignment between algorithmic capabilities and the essence of humanistic artistic creation, manifested through generated content lacking affective depth and cultural contextual understanding. This deficiency results in formulaic expressions, exemplified by compromised ink-brush vitality in synthetic Chinese paintings and mechanically repetitive motions in AI-generated traditional opera performances. The root cause lies in algorithmic failures to model non-regularized aesthetic logics, such as the liubai (intentional void) philosophy in Chinese literati painting or the tacit craftsmanship intelligence inherent in intangible cultural heritage practices. Furthermore, within cultural transmission contexts, AI systems occasionally fabricate historical facts or misinterpret traditional symbolic semantics—as seen in erroneous fusions of dynastic ornamental patterns—primarily due to training data noise and fragmented cross-temporal knowledge associations, ultimately producing temporally discordant outputs.

1.2. Regulatory gaps

The fundamental conflict arises from a structural disconnect between existing legal frameworks and digital cultural production paradigms. Rights attribution for AI-generated content faces tripartite ambiguities: subject ambiguity (indeterminate authorship among fragmented data contributors), object ambiguity (unclear copyright status of derivative works such as digitized Dunhuang fresco replicas), and boundary ambiguity (ill-defined adaptation thresholds for traditional cultural expressions). These uncertainties perpetuate persistent controversies regarding the ontological classification of algorithmically synthesized cultural assets as novel creative works.

1.3. Ethical dilemmas

The core conflict stems from inherent tensions between technological efficiency and cultural ethics, manifested through risks of algorithmic colonialism. This phenomenon marginalizes minority visual languages via Western aesthetic-dominant generative models and transgresses cultural taboos when converting sacred totemic symbols into decorative patterns. Such violations fundamentally arise from incompatibility between the value assumptions embedded in technical systems and the ethical topology of traditional communities. When AI-generated content causes cultural harm (e.g., distorted religious iconography), responsibility attribution becomes fragmented across the development chain, resulting in systemic accountability dilution.

Building upon a critical synthesis of foundational theories in cognitive intelligence, this research focuses on:

Conducting a systematic analysis of its current convergence status within cultural industries.

Diagnosing prevailing challenges in cross-domain integration.

Proposing evidence-based development trajectories and policy-responsive strategies.

These tripartite objectives aim to establish a theoretically grounded reference framework for future scholarly inquiry and evidence-informed policymaking.

2. Fundamental principles underpinning cognitive-cultural convergence

Cognitive Intelligence (CI) constitutes an advanced AI paradigm targeting the emulation and extension of human cognition-spanning perception, reasoning, and decision-making. Its architecture integrates deep learning, knowledge graphs, and semantic analytics, with real-time model optimization via feedback loops, enabling complex knowledge processing [6]. As content-production systems, cultural industries demonstrate irreversible digital-intelligent convergence. Their restructuring constitutes a cognitive-technological realignment, enabling automated curation and adaptive delivery of cultural assets to forge experience-focused cultural ecologies. Theoretical bases include:

Media Technology Evolution Theory: The production and dissemination of cultural content are constrained by the development of media forms. Cognitive intelligence is regarded as the driving force of the “fifth media revolution”, capable of redefining modes of expression and audience relationships [7].

Technology–Culture Coupling Theory: This theory posits a nonlinear interactive relationship between technological systems and cultural systems, whereby technological innovation can trigger paradigm shifts in cultural expression [8].

Knowledge Computing Theory: This approach enables the semantic modeling of cultural knowledge through graph construction and inference mechanisms, and it serves as the core methodological support for applying cognitive intelligence within cultural contexts [9].

The empowerment of the cultural industry by cognitive intelligence is primarily manifested in three key areas:

intelligent content generation, user behavior insights, and optimization of interactive experiences. These aspects collectively provide both theoretical and technological foundations for building new forms of cultural productivity.

Intelligent content generation: Cognitive intelligence, through technologies such as natural language processing, image recognition, and semantic modeling, enables the automatic generation and creative reconstruction of cultural content. Significant progress has been made in the digital preservation and dissemination of Dunhuang culture. For example, Han et al. proposed a high-resolution mural restoration framework based on Generative Adversarial Networks (GANs), which effectively reconstructs damaged Dunhuang mural images [10]. Furthermore, their DiffuMural model employs a multi-scale diffusion mechanism to restore murals with high fidelity, preserving the stylistic consistency of the original artworks [11]. These advancements not only enhance the visual dissemination capabilities of cultural heritage but also open new avenues for the contemporary expression of traditional art.

User behavior insights: Leveraging multimodal analysis and behavioral modeling, cognitive intelligence can provide deep insights into user interests and cultural engagement patterns. This facilitates precise content recommendation and personalized presentation. For instance, the VirtuWander system, empowered by large language models, enhances multimodal interactivity in virtual tours, enabling personalized cultural experiences based on users' behavior and preferences [12].

Optimization of Interactive Experiences: Cognitive intelligence also enhances human-computer interaction through technologies such as speech recognition, natural language understanding, and virtual agents. In the VirtuWander system, AI-powered virtual tour guides can engage users in real-time voice interaction, offering detailed explanations of the artistic features of the Mogao Caves. The system also provides adaptive responses based on user inquiries, significantly improving the immersive experience of cultural tourism and strengthening user engagement and emotional connection [12].

3. Current status analysis of integrated development

3.1. Industry application scope expansion

Cognitive intelligence has been preliminarily deployed in fields such as news dissemination, animation, film production, and intangible cultural heritage. For example, Xinhua News Agency's "Xinhua Zhiyun" platform enables real-time global news collection and automatic report generation [13]; Bilibili uses speech recognition and AI-generated subtitles to enhance video consumption experience [14]; projects like Digital Dunhuang and Digital Sanxingdui utilize cognitive models to build immersive cultural communication scenarios [15–16].

3.2. Rapid improvement in content generation quality

AI-generated content (AIGC) is a core achievement of cognitive intelligence applications. Large language models such as Baidu's Wenxin Yiyan, Alibaba's Tongyi Qianwen, and OpenAI's GPT-4 have demonstrated capabilities in generating texts, including news, poetry, novels, and scripts [17–18]. For the 2024 CCTV Spring Festival Gala, an AI-assisted script co-creation mechanism was introduced for the first time, reducing the initial draft generation time to one-tenth of the traditional approach.

3.3. Enhanced user profiling and precision distribution improve communication efficiency

Cognitive intelligence constructs fine-grained user profiles through multi-source data fusion and behavior modeling, enabling personalized content distribution. Platforms like Douyin's "thousand faces" recommendation

algorithm and Ximalaya's smart radio significantly enhance user engagement [19–20]. According to statistics, Kuaishou disclosed in its 4Q24 management presentation that "the average daily usage time per user is approximately 126 minutes", and daily active user time continues to grow [21].

3.4. Intelligent cultural exhibition and museum scenarios become new hotspots

AI voice guides, virtual docents, and digital twin spaces have been widely deployed in museums, art galleries, and cultural centers. For example, For instance, data indicates that a method has been proposed to construct a knowledge graph for cultural heritage data (such as the Palace Museum's porcelain collection) by extracting entity-relationship triples from fragmented and heterogeneous sources. Models are then employed to predict missing information, thereby enhancing the knowledge graph's completeness. This approach represents an application of cognitive intelligence within cultural heritage contexts, enabling semantic modeling, reasoning, and personalized access to cultural knowledge [22].

4. Principal challenges

4.1. Insufficient technical maturity and application adaptability

Despite significant breakthroughs, cognitive intelligence remains constrained by bottlenecks in cultural semantic comprehension, style transfer, and multimodal generation. For instance, in scriptwriting tasks, AI systems frequently fail to interpret complex character relationships and narrative tension, resulting in structurally fragmented and logically inconsistent outputs.

4.2. Dilemmas in cultural originality and artistic expression

AIGC typically relies on existing materials for imitative learning, which results in homogeneity across creative outputs. The majority of works are generated using templated compositions, exhibiting limited stylistic innovation. Prolonged dependence on AI-generated content may constrain human originality and lower the aesthetic ceiling of the cultural and creative industries [23].

4.3. Escalating legal, ethical, and governance risks

Critical concerns persist regarding:

Authenticity verification of AI-generated content (e.g., 2023 virtual anchor incidents disseminating disinformation)

Ambiguous copyright boundaries (e.g., commercial exploitation of deceased artists' stylistic replicas)

Regulatory vacuums: China's current lack of AIGC-specific legislation creates governance gray zones.

4.4. Digital divides and resource disparities

SMEs and regional cultural institutions face threefold barriers:

Technical thresholds (limited AI integration capabilities)

Capital constraints (high computational infrastructure costs)

Talent shortages (insufficient AI literacy)

Small and medium-sized cultural enterprises, as well as regional museums and cultural institutions, often face significant barriers to adopting AI technologies due to high technical thresholds, substantial capital requirements, and a shortage of skilled personnel. These challenges hinder their ability to compete with leading platforms,

contributing to a trend of "platform oligopoly" in the allocation of cultural resources [24]. Furthermore, surveys by relevant cultural heritage organizations reveal that challenges and opportunities arise when implementing artificial intelligence (AI) and machine learning (ML) methods and tools within cultural heritage institutions (CHI). Budget constraints and lack of technical expertise are frequently cited barriers to AI adoption [25].

5. Future trends and development pathways

5.1. Multimodal cognitive models as the technological core

With the continuous advancement of computational power and algorithmic design, multimodal cognitive intelligence models have become a pivotal technological trajectory in the intelligent transformation of the cultural and creative industries. Cutting-edge models such as Google Gemini and OpenAI's GPT-Vision have demonstrated integrated understanding and generation capabilities across modalities, including text, image, audio, and even video, thereby enabling more natural content integration and expressive creativity in cultural production processes [26–27].

In the future development of cognitive intelligence, multimodal cognitive models are poised to become a technological cornerstone, enabling machines to integrate and reason across heterogeneous modalities such as visual, linguistic, and auditory signals [28]. By merging perception with symbolic and linguistic representations, such models not only enhance semantic comprehension but also foster the development of more human-like cognitive abilities, including common-sense reasoning, contextual learning, and adaptive decision-making [29]. This convergence signifies a paradigm shift in cognitive architecture—from monomodal or narrow-domain specialized systems towards holistic cognitive frameworks. Such systems are better equipped to adapt to complex real-world environments and human-machine interaction scenarios.

5.2. Cognitive intelligence driving the restructuring of the cultural industry chain

Cognitive intelligence is likely to reshape the cultural-industry ecosystem by supporting multiple links of the value chain — from ideation and content production to distribution and user feedback — rather than instantly replacing existing industry structures [30]. AI-assisted tools for script development, automated dubbing/localization, and AI-assisted visual effects are increasingly available and are already being piloted in media and entertainment production, helping to reduce certain production costs and accelerate workflows. At the same time, deep-learning-based user-behavior analysis and recommender systems have become a core component of digital platforms' audience targeting and content distribution strategies. Finally, market research in China suggests that many tourists welcome technology-enhanced experiences: the China Tourism Research Institute's National Smart Tourism Development Report 2023 reported that more than 80% of surveyed visitors said they would be willing to spend more on travel experiences that integrate advanced technologies [31].

5.3. Accelerated policy support and standards development

To enhance the integration of cognitive intelligence into the cultural industry, several countries have implemented pertinent policies. China's 14th Five-Year Plan for National Economic and Social Development (2021–2025) outlines strategies to digitize cultural industries, accelerate the development of new types of cultural enterprises, and strengthen digital creativity, online audio-video, digital publishing, digital entertainment, and online broadcasting industries [32]. Additionally, the International Organization for Standardization (ISO) is actively developing ethical guidelines and technical standards for AI-generated content to ensure the healthy and

sustainable development of the industry [33].

5.4. Ethical norms and copyright protection as core issues

With the widespread adoption of AI-generated content (AIGC) technologies, balancing technological innovation and copyright protection has become a central concern. The U.S. Copyright Office has begun legal assessments regarding the ownership rights of AI-generated works, while China is actively developing intellectual property protection frameworks for AI-created content. In the future, blockchain-based copyright traceability and protection technologies may become effective means to safeguard original creators' rights.

5.5. Formation of intelligent cultural service ecosystems

The future cultural industry is expected to develop an open ecosystem driven by cognitive intelligence, bringing together content creators, technology providers, users, and regulatory bodies. Through data sharing and collaborative innovation, this ecosystem will enable the production, dissemination, and value realization of intelligent content. For example, leading companies such as Tencent, Alibaba, and ByteDance have established AI-centric cultural content platforms that facilitate cross-platform circulation and commercial monetization of cultural content.

6. Conclusion

This study demonstrates that the integration of cognitive intelligence (CI) and cultural industries constitutes a paradigm-shifting transformation, yet faces persistent challenges across technical, creative, and governance dimensions. Key findings reveal:

Technical constraints: The technical bottleneck of semantic understanding and multimodal generation restricts the quality of art, and the narrative coherence of the script creation system is lower than the human benchmark.

Aesthetic homogenization: The derivative imitation model leads to homogenized creation, with the majority of AI-generated artworks exhibiting compositional redundancy.

Regulatory voids: The absence of clear regulations regarding copyright ownership and content authentication exacerbates ethical risks, as there is a lack of corresponding national policies to provide effective oversight.

Resource stratification: The concentration of innovation capital and computing power resources primarily in large corporations such as Tencent, ByteDance, and Alibaba in China has, to some extent, hindered the deep integration of small enterprises with the cultural production sector.

To advance toward human-AI symbiosis, we propose a tripartite framework, as illustrated in **Figure 2**.

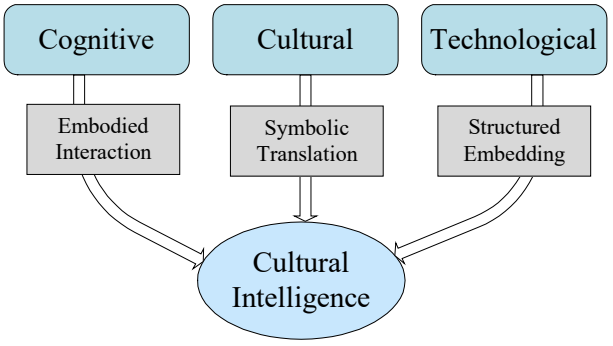

Figure 2. Tripartite framework

Cognitive Dimension: By leveraging technologies such as artificial intelligence, big data, and neural networks, inherent cognitive patterns can be expanded, enabling a multi-perspective understanding of phenomena.

Cultural Dimension: Through the utilization of cultural capital and the experience economy, cultural dissemination and inculcation are employed to attract user engagement and consumption, which in turn feeds back into the market, fostering a cyclical integration within the cultural economy.

Technological Dimension: By constructing actor-networks, applying novel cultural algorithms, and redefining policy boundaries, the cultural and social systems can be upgraded across multiple dimensions.

A schematic diagram of the actor network is shown in **Figure 3**.

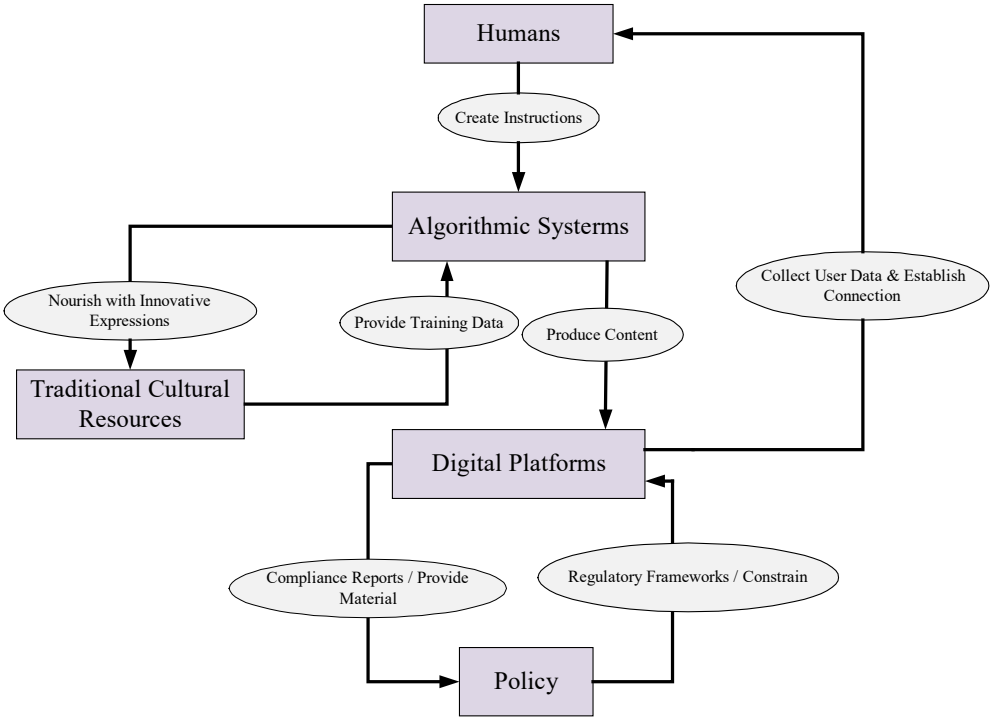

Figure 3. A schematic diagram of the actor network

Figure 3 illustrates the actor-network schematic. Humans produce algorithmic systems through instructional design. These algorithmic systems subsequently enrich traditional cultural resources via innovative expressions, while traditional cultural resources feed back into algorithmic systems as training data. Algorithmic systems generate content for digital platforms, which provide regulatory bodies with policy development materials through compliance reporting. Policy frameworks then constrain digital platforms through regulatory mechanisms. Finally, digital platforms establish human connections via user data collection.

Figure 4 depicts a future-oriented cultural intelligence paradigm proposing five key functions:

Cross-Modal Understanding: Enables multidimensional, multi-perspective analysis of entities. Examples: Dialect speech emotion recognition; visual-semantic parsing of cultural relics.

Creative Co-Generation: Facilitates simultaneous cultural intelligence recognition and collaborative generation of novel creative content. Examples: AI-assisted scriptwriting systems; innovative design of traditional patterns.

Dynamic Propagation Optimization: Supports cross-platform content dissemination while enabling precise user profiling for targeted delivery and enhanced user experience.

Sustainable Innovation: Revitalizes traditional craftsmanship for improved heritage preservation; transforms cultural techniques into digital assets for efficient management and value conversion.

Ethical Decision Framework: Requires safeguarding cultural boundaries and conducting rigorous sensitivity assessments of traditional cultural contexts.

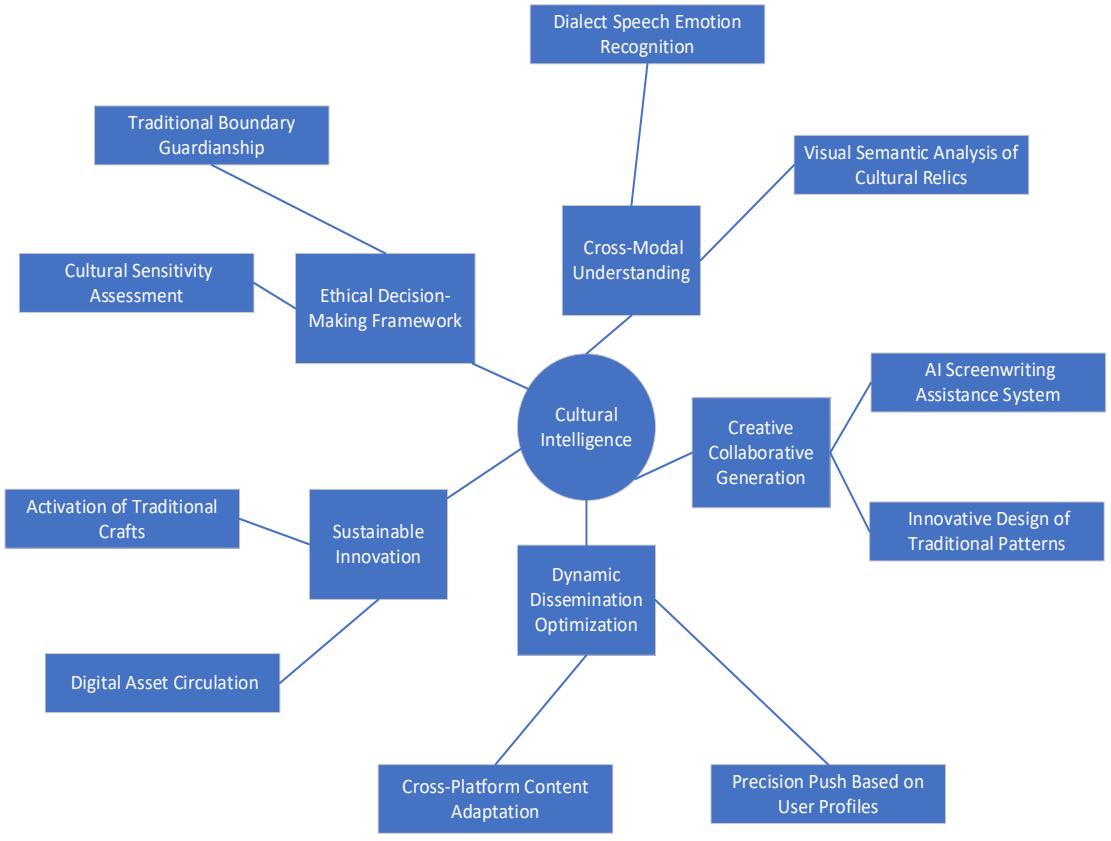

Figure 4. Future-oriented cultural intelligence paradigm

Future research should prioritize: First, cross-modal creativity metrics beyond Turing tests. Then, sandbox regulatory experiments in cultural free-trade zones. Finally, decentralized AI platforms for SMEs.

This integrated approach promises to catalyze a new renaissance in cultural production—where cognitive technologies amplify rather than replace human creativity—ultimately forging resilient, equitable, and aesthetically progressive cultural ecosystems.

To advance the intelligent transformation of the cultural industries, it is imperative to:

Strengthen technology-driven innovation.

Refine institutional support mechanisms.

Construct a collaborative and mutually beneficial ecosystem.

Thereby enables the deep integration of cultural technologies and fosters sustainable innovation.

Disclosure statement

The authors declare no conflict of interest.

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