

Research on Dynamic Evaluation and Optimization Strategies of Tourists' Immersive Experience Based on Multi-platform UGC Texts in Smart Tourism Scenarios: A Case Study of Chang'an 12th Hour Theme Street

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ABSTRACT

With the deep integration of smart tourism and immersive cultural tourism, user-generated content (UGC) has become the core data source for capturing tourists' experiential perceptions. Taking the Xi'an Chang'an Twelve Hours themed street as a case study, this paper collects nearly two years of UGC texts (a total of 13,864 entries) from three major platforms—TikTok, Xiaohongshu, and Ctrip—and employs LDA topic mining, sentiment analysis, and staged analysis to construct a dynamic evaluation framework for tourist immersive experiences. This framework identifies the emotional tendencies and temporal patterns of core experience themes and extracts key factors influencing the experience. The study reveals that the core value of the street's immersive experience lies in the dual dimensions of "cultural perception + technological interaction," with satisfaction levels exhibiting significant fluctuations during holidays and special events. Technological integration must balance "immersion" and "convenience," as excessive reliance on devices may lead to experience discontinuity. Based on these findings, strategies are proposed across three dimensions—smart operation, product optimization, and service enhancement—to provide references for the sustainable development of immersive cultural tourism projects.

KEYWORDS

Smart Tourism; User-Generated Content (UGC); Immersive Experience; Dynamic Evaluation

1. INTRODUCTION

1.1. Research Background

Amid the rapid advancement of information technology, smart tourism has emerged as a pivotal driver for transforming and upgrading the tourism industry. Immersive experiences, with their unique appeal, have increasingly become the core force behind achieving high-quality development in the cultural and tourism sector. This trend not only meets tourists' demand for premium travel experiences but also enjoys strong policy support. In 2023, the Ministry of Culture and Tourism issued the "Opinions on Promoting High-Quality Development of the Online Tourism Market," which explicitly called for leveraging advanced technologies such as 5G, AI, and AR to create "immersive and interactive" tourism scenarios, providing clear policy guidance for the growth of immersive experiences in the cultural and tourism field.

As an advanced form of tourism experience, immersive experiences integrate technologies such as VR/AR, smart sensing systems, and narrative spatial design to create highly engaging, emotionally resonant, and immersive environments for visitors. This approach plays a crucial role in enhancing the core competitiveness and achieving sustainable development of tourist destinations like themed

districts and cultural attractions. The Chang'an Twelve Hours Themed District, China's first immersive Tang Dynasty culture space, successfully recreates authentic urban scenes from the prosperous Tang era while seamlessly combining NPC interactions with digital technologies including AR/VR and AI-powered face-swapping cameras, creating a fully Tang-themed immersive environment. It has not only been recognized as one of the Ministry of Culture and Tourism's inaugural "National Smart Tourism Immersive Experience Space" demonstration projects but has also rapidly become a popular destination in the tourism industry. By meticulously replicating Chang'an's urban landscape and daily life during the Tang Dynasty, the district transports visitors back in time, enables deep participation in cultural activities, fully meets tourists' demand for immersive experiences, and provides a valuable practical model for the development of immersive tourism initiatives.

With the widespread adoption of the internet and mobile devices, tourists have generated a vast amount of user-generated content (UGC) during their travels. This UGC is widely distributed across major platforms such as Weibo, TikTok, Ctrip, and Xiaohongshu, encompassing various formats including travel experiences, reviews, photos, and videos shared by tourists. UGC not only accurately reflects tourists' travel experiences and perceptions but also provides rich and valuable data resources for tourism research, laying a solid foundation for in-depth exploration of tourist experiences.

However, existing research on immersive tourism exhibits significant shortcomings. On one hand, studies predominantly focus on the mechanisms underlying the creation of immersive tourism scenarios, with limited attention paid to the dynamic evaluation of tourists' immersive experiences; on the other hand, even when addressing immersive experiences, research often relies heavily on traditional methods such as questionnaires and field interviews. While these conventional approaches can yield structured data, they suffer from inherent limitations including small sample sizes, delayed data availability, and an inability to fully capture the dynamic nature of tourists' experiences. In reality, tourist experiences are complex processes that evolve continuously across time, space, and specific contexts. Traditional research methods are fundamentally incapable of providing a comprehensive, continuous, and accurate portrayal of these experiences, which significantly hinders the in-depth development of immersive tourism research.

In the current landscape of intense market competition in the tourism industry, enhancing visitor experience has become a critical factor for destinations and attractions to maintain their core competitiveness. Building on this context, this study focuses on the cutting-edge field of smart tourism development, taking the Chang'an Twelve Hours themed district—a representative immersive tourism case—as its subject. Utilizing multi-platform UGC text data, it conducts dynamic evaluation of visitor immersive experiences and proposes targeted optimization strategies accordingly. This research not only addresses gaps in existing immersive tourism studies but also provides valuable insights for other tourist destinations in developing smart tourism infrastructure and creating immersive experiences, thereby fostering high-quality, sustainable growth across the entire tourism sector.

1.2. Research Significance

1.2.1. Theoretical Significance

This study enriches the content framework of smart tourism research by integrating UGC text analysis with assessments of tourists' immersive experiences, thereby expanding both methodologies and perspectives in this field and providing new insights for future research. It enhances our understanding of the mechanisms underlying tourists' immersive experiences and their influencing factors, while further clarifying the value and application potential of UGC in tourism studies.

1.2.2. Practical Significance

This initiative helps operators of the Chang'an Twelve Hours themed district gain deeper insights into visitor needs and experience pain points, enabling targeted optimization of products and services to enhance visitor satisfaction and loyalty while strengthening market competitiveness. It provides practical references for other tourist attractions and destinations in developing smart tourism solutions and creating immersive experiences, promotes industry-wide application and advancement of UGC data-driven visitor experience optimization, and drives innovative development and transformation within the tourism sector.

1.3. Research Methods

1.3.1. Multi-platform UGC Text Collection

Using web crawling technology, we collected UGC text data related to the "Chang 'an Twelve Hours" themed street area from three popular platforms—TikTok, Ctrip, and Xiaohongshu—including tourist reviews, travelogues, and video descriptions—to ensure broad and diverse data sources. A reasonable time range was set to obtain tourists' experience feedback across different periods, facilitating dynamic analysis.

1.3.2. Text Analysis Methods

Using natural language processing (NLP) techniques and text mining tools, the collected UGC texts undergo preprocessing including text cleaning, tokenization, and part-of-speech tagging. Emotional analysis algorithms are employed to determine the emotional tone (positive, negative, or neutral) in tourist-generated content, thereby analyzing their attitudes toward various aspects of the neighborhood experience. Through topic models such as LDA, potential themes are identified to extract key elements of interest, such as neighborhood ambiance recreation, cultural activities, and service quality.

2. RELEVANT CONCEPTS AND LITERATURE REVIEW

2.1. Relevant Concepts

2.1.1. Smart Tourism

The concept of smart tourism stems from the deep integration of information technology and the tourism sector. Its international origins can be traced to IBM's "Smart Planet" initiative in 2008, which was later further promoted by the United Nations World Tourism Organization (UNWTO) as part of its "smart tourism" development strategy. In China, the concept was first introduced by Zhenjiang City in 2010, designated as a key industry priority by the National Tourism Administration in 2011, and explicitly endorsed by the State Council in relevant documents in 2013 with directives to expand information service offerings and advance smart tourism development, marking its official elevation as a national-level tourism development direction.

Smart tourism typically refers to a new model of high-quality tourism development that fully leverages next-generation information technologies such as internet big data, cloud computing, artificial intelligence, and virtual reality. This approach aims to digitize, network, and intelligentize tourism governance, services, marketing, and experiences, thereby enhancing management efficiency, enriching tourism product offerings, and improving visitor experiences. Its essence lies in utilizing digital technologies to integrate tourism resources, enabling real-time monitoring, efficient dissemination, and intelligent processing of tourism information, which ultimately boosts operational efficiency in the industry and elevates visitor satisfaction. Scholars like Zhang Lingyun (2012) defined smart tourism as an advanced stage of tourism informatization, emphasizing the delivery of personalized services and intelligent public support through technological means. Subsequent

research published in 2025 further highlighted that the integrated application of technologies such as artificial intelligence and blockchain is transforming smart tourism into a comprehensive ecosystem encompassing destination management, service optimization, and marketing initiatives.

2.1.2. UGC

The concept of UGC was introduced in 2005, yet there is currently no universally accepted definition for it. User-generated content (UGC), also known as User-created Content (UCC) or Consumer Generated Media (CGM), refers to any text, images, audio, video, or other materials created by users and published online in various formats. It represents an emerging model for creating and organizing online information resources within the Web 2.0 ecosystem. UGC is characterized by three key features: reliance on online publishing platforms, a certain degree of innovation in content, and creation by non-professionals or non-authoritative organizations. Common distribution channels include microblogs, blogs, video-sharing sites, wikis, online Q&A platforms, and social media networks (SNS).

In practical research, scholars often favor a broader definition of UGC and a flexible conceptual framework. UGC can be understood either as static online information resources created by users or as dynamic patterns of user-generated creation; alternatively, from an ecological perspective, it can be interpreted as a distinct order deeply intertwined with user communities, social networks, dissemination channels, and online/virtual ecosystems. The concept of UGC can be clarified through its four dimensions: Who (user types and roles), What (content types and attributes), Why (motivations behind content creation), and How (creation patterns).

The development of the UGC model has gone through multiple stages, from the emergence of personal websites to the rise of forums, blogs, and video platforms, and further evolving towards mobility, mass adoption, and integration. China's UGC model is closely linked to users, achieving significant progress in five dimensions: content aggregation, user retention, video social interaction, mobile applications, and monetization models. With the continuous transformation and evolution of the internet and the advent of the big data era, an increasing amount of unstructured data, heterogeneous content, and personalized content will bring more opportunities and challenges to both academia and industry.

2.1.3. Immersive Experience

Flow Experience, also known as Flow Theory or immersive experience, was first proposed by M. Csikszentmihalyi in 1975 [1]. In 1988, he further elaborated that flow occurs when individuals act according to their psychological drive, representing the manifestation of conscious motivation. He also emphasized that flow arises when challenge and skill levels are balanced; in other words, people enter a state of flow when these two factors are in equilibrium. Additionally, flow is a subjective and transient experience, which explains why individuals are motivated to persist in such activities. In positive psychology, flow refers to a state where individuals become fully immersed in an activity, with focused attention and the filtering out of all irrelevant stimuli. It constitutes a positive psychological experience that generates significant pleasure during engagement, encouraging repeated participation without fatigue.

Immersive experience in the tourism sector refers to a panoramic interactive experience involving visual, tactile, auditory, and olfactory elements that creates a sense of being fully immersed. The rise of internet technology and the application of advanced technological methods are ushering humanity into an era of "time travel" and "virtual worlds," marking a new age of experiential tourism for the industry. Immersive tourism emphasizes the visitor's direct personal engagement; only by closely integrating oneself with the travel experience can it truly be elevated to what constitutes genuine travel. By fully immersing themselves in the itinerary, tourists avoid feeling fatigued from the travel experience, making immersive tourism a highly naturalized form of travel.

2.2. Literature Review

2.2.1. International Research

The international academic community has developed a relatively systematic theoretical framework for research on immersive experiences. Scholars in environmental psychology, such as Zatori et al., identified three core elements of immersive environment design—spatial narrative, multisensory stimulation, and social interaction—and empirically demonstrated a positive correlation between scene authenticity and tourist engagement. Xue et al. argued that digital technologies are blurring the boundaries between the real and virtual worlds while enhancing immersion across both online and offline experiences, highlighting their pivotal role in improving tourist immersion. From the perspective of flow theory, Csikszentmihalyi's [2] seminal research underscores how the balance between visitor skills and scene complexity determines deep immersion experiences, a principle widely applied in theme park design at destinations like Disney. Regarding technological empowerment, Gretzel et al. [3] proposed a smart tourism technology framework emphasizing the value of real-time data feedback systems (e.g., crowd monitoring, AR guided tours) in personalizing experiences, while Tussyadiah used Disney's MagicBand wearable device to demonstrate the practical significance of behavioral data capture for optimizing visitor flow patterns. Bogicevic et al. argue that immersive experience projects—such as immersive scripts, escape rooms, theater performances, and immersive shows—primarily utilize digital virtual technologies or augmented reality to present story themes, create immersive atmospheres, enhance tourists' sense of participation and interaction, and elevate their overall immersive experience.

Furthermore, international research has made significant progress in UGC text analysis. Karahasanovi et al. [4] conducted three distinct studies—macro-level, group-level, and individual-based—to examine older users' needs regarding consumption, sharing, and collaborative UGC in the new media era. Molyneaux et al. [6] employed YouTube as a case study to explore gender differences in creating and consuming online video UGC. Krumm et al. [5] utilized digital networks and mobile devices to apply UGC technologies in data collection, pattern recognition, community building, and artistic presentation. Girardin et al. leveraged network data generated by travelers' mobile devices and travel photos to identify spatiotemporal information about travelers' locations and activities, integrating this approach with traditional spatiotemporal databases to significantly enhance data accessibility and analytical agility.

2.2.2. Domestic Research

Domestic research in the context of cultural-tourism integration has identified immersive experiences as a key development direction for tourism destination products and services. This approach primarily leverages digital technologies to closely integrate tourists' psychological spaces with destination physical environments, enhancing scene immersion and deepening visitor memories. Teng Lefa et al. [15] found that destinations often lack sufficient immersive elements, suffer from clichéd thematic narratives, exhibit strong content homogeneity, and offer limited immersive experiences. Cold Rongliang's study on Chuzhou's local cultural preservation utilized visual imagery and 3D digital technologies to enable visitors to immerse themselves in virtual settings, experiencing Chuzhou's history, art, and traditions while promoting cultural preservation. He Jing et al. [10] developed a big data-driven experience optimization framework, demonstrating a positive correlation between data collection quality and immersion levels, though data security risks may undermine experiential trust. Xu Ruyi et al. [16] highlighted how advancements in high-immersion technologies are driving destinations toward greater interactivity and digital empowerment of travel experiences. Additionally, existing studies explore the practical application of embodied theory in immersive tourism experiences, examining the role of bodily and emotional interactions. Hu Yingchun et al. [11] analyzed the formation of immersive experiences from a psychosomatic harmony perspective, emphasizing that visitor engagement, scene immersion, and physical/mental presence are critical determinants of experience quality.

In the field of UGC analysis, the vast amount of user-generated content on online travel platforms provides travelers with diverse and rich information, which Xu Ruoran noted aligns with the development trends of modern smart tourism. Deng Ning argues that tourism UGC content is characterized by authenticity, objectivity, and large data volumes [9]; thus, leveraging such content to identify users' genuine needs from the demand side can offer destination marketing organizations new approaches and insights for enhancing destination image promotion. Lu Luzheng et al., through UGC text mining, conducted an in-depth study of tourism visitor flow networks at both regional and node levels in Xi'an, providing valuable references for tourism development in other cities [13]. Zhang Chubing et al., applying interaction theory and flow experience theory from a user-product interaction perspective, proposed two recommendations—constantly addressing users' expectations regarding interactivity and strengthening interactive experiences within tourism apps—to improve user loyalty and stimulate purchase intent [17].

2.2.3. Commentary

A systematic review of domestic and international literature reveals that, theoretically, the academic community generally agrees that immersive experiences rely on technological support and cultural foundations, and multi-platform UGC has become a crucial data source for understanding tourist emotions. However, existing research has failed to effectively correlate real-time smart system data (such as visitor flow and dwell time) with UGC-based emotional data; moreover, immersion measurement often relies on single-dimensional scales, making it difficult to capture the complexity of multi-sensory interactions. Therefore, this study takes the Chang'an Twelve Hours district as a case study, constructs a "multi-platform UGC spatiotemporal emotional atlas" to quantify the dynamic evolution of immersive experiences, and systematically identifies the core characteristics of tourist immersion, the patterns of emotional development, and their influencing factors.

3. RESEARCH DESIGN

3.1. Case Selection

This study selects the Chang'an Twelve Hours themed district as a core case study. It represents a typical example of a new type of immersive smart tourism experience space in China, centered on Tang culture and featuring an integrated experience system that combines "exploring the Complete Tang Space, experiencing Tang-style urban life, participating in thematic immersive activities, enjoying Tang-era musical performances, and engaging in cultural social leisure." Its key characteristic lies in utilizing real-person, real-scene interactions as the foundation while deeply integrating digital technologies such as augmented reality (AR), virtual reality (VR), and artificial intelligence (AI) with cultural creativity elements. Through an innovative model of cultural-tourism integration and virtual-real fusion, it achieves seamless integration of thematic landscape design, performance content creation, and commercial layout, ultimately creating novel cultural-tourism products and consumption scenarios that enable visitors to fully engage with and immerse themselves in the essence of Tang culture and the daily life of Tang-era cities.

In practical application and management scenarios, this district enhances its immersive experience and smart functionality through multidimensional technological integration: Firstly, by leveraging specialized equipment combined with audio-visual and lighting technologies, it creates diverse cultural art spaces and distinctive light installations, offering visitors a truly immersive Tang Dynasty-themed experience. Secondly, it deeply explores the essence of Tang culture and urban folk traditions, integrating high-tech lighting art into the overall ambiance to transcend traditional "sightseeing-oriented" approaches, establishing a new cultural tourism model combining immersive experiences and interactive participation. Thirdly, in smart management, all access gates employ facial recognition systems for rapid identity verification and ticket validation, ensuring both security and efficiency while enabling precise crowd control at entry/exit points and throughout the area.

Additionally, real-time crowd monitoring coupled with performance schedules enables dynamic tracking of visitor distribution, allowing intelligent route planning for optimal viewing conditions with minimal crowds. Fourthly, an innovative payment system called "Kaiyuan Tongbao" incorporates Tang Dynasty cultural elements into transaction details, featuring built-in encryption chips that ensure anti-counterfeiting authentication and data security, further enhancing cultural immersion. Through comprehensive technological integration and coordinated services, the district has achieved intelligent management upgrades, creating a cutting-edge smart tourism space characterized by immersion, modernity, smart functionality, and cultural integration. The selection of the Changan Twelve Hours themed district as the research case is primarily based on the following three criteria:

(1) High density of smart technologies: The district integrates a wide range of smart tourism applications, including AI face-swapping, VR tours, intelligent crowd monitoring, facial recognition verification, and customized payment systems. These technological applications align closely with the research scope of "smart tourism scenarios," providing a prime example for studying how smart technologies influence immersive experiences.

(2) Distinctive Immersive Experience Feature: Centered around the popular IP "The Longest Day in Chang'an", the district employs diverse elements—including scene recreation, NPC interaction, and Tang-style performances—to authentically recreate daily life in the prosperous Tang Dynasty. It fulfills visitors' immersive experience needs across visual, auditory, and interactive dimensions, aligning perfectly with the core research focus of "immersive experience" and providing robust support for related studies on this dimension and its influencing factors.

(3) Rich UGC data: This neighborhood enjoys extremely high topic popularity on mainstream social platforms such as TikTok and Xiaohongshu, with related topics having garnered over 5 billion views. There is an ample and diverse range of UGC (User-Generated Content)—including texts, images, and videos—spontaneously shared by tourists based on their personal experiences, providing researchers with massive and authentic primary data support that meets the requirements for data scale and quality specified in the research methodology of "dynamic evaluation based on multi-platform UGC texts."

3.2. Data Sources and Processing

3.2.1. Data Sources

Three representative platforms were selected to cover various experience-sharing scenarios, with data collection spanning from May 2023 to April 2025 (a total of 24 months). TikTok: short video captions and comments (6,218 entries, accounting for 44.9%), focusing on immediate experience sharing; Xiaohongshu: image-and-text notes and product recommendation content (4,832 entries, accounting for 34.9%), emphasizing in-depth experience summaries; Ctrip: tourist reviews and travel diaries (2,814 entries, accounting for 20.2%), concentrating on comprehensive experience evaluations. After manual screening to exclude irrelevant texts (e.g., those merely mentioning "The Longest Day in Chang'an" without experiential descriptions), a final dataset of 13,864 valid entries was retained.

3.2.2. Data Preprocessing

(1) Cleaning: Remove garbled characters, special symbols (such as "@#¥"), and duplicate text (when the same user posts identical content multiple times);

(2) Word segmentation and destop word removal: Use HanLP for Chinese word segmentation, removing common stop words (e.g., "I", "today") and domain-specific stop words (e.g., "Xi'an", "subway", unrelated to user experience).

(3) Keyword extraction: Identify high-frequency keywords (e.g., "Tang Dynasty style," "AI face-swapping," "queuing," "performing arts") to lay the groundwork for thematic analysis.

3.3. Construction of Evaluation Dimensions for Immersive Experiences

Drawing on existing research and incorporating the "wisdom + culture" distinctive features of Chang'an Twelve Hours, we have developed an evaluation system comprising four primary dimensions and twelve secondary indicators, as shown in Table 1.

Table 1. Evaluation Dimension System of Tourists' Immersive Experience

Primary Dimension	Secondary Indicator	Indicator Description
Sensory Immersion	Scene Restoration Degree, Technical Visual Sense	e.g. "Authenticity of Tang Dynasty Style Architecture", "Clarity of VR Images"
Cognitive Immersion	Cultural Perception Degree, IP Fit Degree	e.g. "Deepened Understanding of Prosperous Tang Culture", "Consistent with the Drama IP"
Emotional Immersion	Emotional Pleasure Degree, Experience Surprise Sense	e.g. "Very Happy", "AI Face Swap Exceeded Expectations"
Social Immersion	Interaction Participation Degree, Sharing Willingness	e.g. "Interacting with NPCs is Fun", "Want to Share on Moments"

4. EMPIRICAL ANALYSIS

4.1. Multi-platform UGC Data Feature Analysis

4.1.1. Time Distribution of Data Volume

(1) Monthly fluctuations: Data volumes peak annually in January (Spring Festival), May (May Day), and October (National Day), accounting for 16.8%, 14.2%, and 15.5% of the annual total respectively; during off-peak periods (February and August), data volume ranges only from 4.5% to 6%, coinciding closely with holiday travel peaks.

(2) Platform differences: TikTok accounts for the highest proportion of data volume (44.9%), followed by Xiaohongshu (34.9%), with Ctrip having the lowest share (20.2%), reflecting that tourists tend to prefer sharing immersive experiences with strong visual appeal on short-video or image-text platforms.

4.1.2. User Geographical Distribution

Local tourists (from Shaanxi) accounted for 41.2%, visitors from neighboring provinces (Shanxi, Henan, Gansu) for 39.5%, and long-distance travelers (from Guangdong, Beijing, Shanghai) for 19.3%, indicating that the area's appeal primarily extends to the northwest and surrounding regions, with its attractiveness to distant visitors still needing improvement.

4.2. Identification of Core Experience Themes

Based on the high-frequency words in the extracted UGC text (Figure 1), five core experience themes were identified using the LDA model ($k=5$), with their respective proportions and representative examples as follows:

(1) Tang-style performances interacting with NPCs (29.1%): Typical review: "Empress Yang's procession was truly breathtaking; the NPCs delivered professional dialogue and even spontaneously challenged visitors to compose poems, creating an immersive experience."

(2) AI/VR-powered smart interactions (24.3%): Typical example: "The AI digital character Li Bai can compose personalized poetry, while VR tours allow visitors to explore the bustling Western Market of the Tang Dynasty—combining cutting-edge technology with rich cultural immersion."

4.4. Dynamic Evaluation of Immersive Experiences

4.4.1. Differences in Experiences Across Multiple Time Scales

Based on the "mean emotional score" and "proportion of negative text", the experience differences under different time scales and significance test results are organized into Table 3.

Table 3. Immersive Experience Differences Under Multi-Time Scales and Significance Test Results

Time Scale	Group	Average Sentiment Score	Negative Text Ratio	Significance Test (p-value)	Conclusion (Significant Difference or Not)
Daily Scale	Peak Hours	0.61	18.2%	t=3.27, p=0.001	Yes (Experience during peak hours is worse than off-peak hours)
	Off-peak Hours	0.70	9.5%		
Weekly Scale	Working Days	0.68	10.3%	t=2.89, p=0.004	Yes (Experience on working days is better than weekends)
	Weekends	0.63	16.7%		
Monthly Scale	Peak Season	0.66	15.1%	F=4.12, p=0.008	Yes (Experience in peak season is slightly worse than off-season)
	Off-season	0.69	8.9%		

According to the data charts, on a daily basis: during peak hours (10:00–16:00), due to "queue congestion" and "high equipment utilization," the proportion of negative texts was 1.9 times higher than in off-peak periods, with an emotional score 0.09 lower; on a weekly basis, weekend overcrowding resulted in "slow service response," and the proportion of negative texts was 1.6 times higher than on weekdays; on a monthly basis, although there are special events during the peak season (such as the cherry blossom season), passenger overload offset some of the positive experience benefits, leaving the emotional score only 0.03 lower than in the off-season—a negligible difference.

4.4.2. Changes in Experience Before and After Key Events

This study selects three typical events to compare immersive experience indicators before, during and after the event, and the statistical results are shown in Table 4, Table 5 and Table 6 respectively.

Table 4. Changes of Immersive Experience Indicators Before, During and After "Sheng Tang Lantern Festival"

Stage	Average Sentiment Score	Proportion of Tang-style Performance Theme	Negative Text Ratio
Before the Event (15 days)	0.65	25.1%	14.2%
During the Event (7 days)	0.76	42.3%	6.8%
After the Event (15 days)	0.68	31.5%	11.5%

Conclusion: In this event, the emotional score increased by 0.11; the proportion of Tang Feng performance-themed content rose by 17.2%, while that of negative texts decreased by 7.4%. The cultural event significantly enhanced the overall experience (t=5.31, p<0.001).

Technical Incident: "VR Device Upgrade" in August 2023

Table 5. Changes of Immersive Experience Indicators Before, During and After "VR Device Upgrade"

Stage	Average Sentiment Score	Proportion of AI/VR Interaction Theme	Negative Text Ratio (Equipment-related)
Before the Event (15 days)	0.58	18.7%	32.5%
During the Event (3 days)	0.62	20.1%	21.3%
After the Event (15 days)	0.71	28.9%	8.2%

Conclusion: Following device upgrades, the emotional score increased by 0.13, while the proportion of device-related negative content decreased by 24.3%. Technical optimizations demonstrated a delayed effect on experience improvement (the most significant results were observed 15 days post-upgrade, $p < 0.001$).

Service-related events: Launch of the Time-Sharing Reservation System in February 2024

Table 6. Changes of Immersive Experience Indicators Before, During and After Launch of Time-Sharing Reservation System

Stage	Average Sentiment Score	Proportion of Service and Environment Theme	Negative Text Ratio (Queuing-related)
Before the Event (15 days)	0.60	12.5%	28.7%
During the Event (10 days)	0.65	10.3%	19.2%
After the Event (15 days)	0.69	8.9%	11.5%

Conclusion: The time-sharing reservation system reduced the proportion of negative queue-related content by 17.2% and decreased attention to service-related themes, demonstrating its effective mitigation of congestion ($p = 0.002$).

5. OPTIMIZATION STRATEGIES

Based on empirical analysis of pain points and dynamic patterns, and leveraging the smart tourism features of *Chang'an Twelve Hours*, this study proposes optimization strategies across three key dimensions:

5.1. Smart Operations: Dynamic Management of Passenger Flow and Equipment

Time-slot reservation and intelligent warning: Based on the real-time frequency of keywords such as "queuing" and "high crowd density" on TikTok and Xiaohongshu (with a threshold set at 500 occurrences per hour), combined with data from smart access gates at scenic spots, a visitor flow warning model is constructed. When the threshold is exceeded, a "peak-hour avoidance reminder" is sent, and three reservation periods— "10:00–14:00", "14:00–18:00", and "18:00–22:00" —are activated to keep queue duration during peak hours within 40 minutes.

Intelligent Equipment Maintenance: Install IoT sensors on AI/VR devices to monitor operational parameters (e.g., failure rate, response speed) in real time. Data is synchronized to the intelligent operations platform, with automatic alerts issued 12 hours before potential failures. A reserve of 15% backup equipment is maintained to ensure replacement can be completed within 30 minutes during failures.

5.2. Product Optimization: Balancing Technology and Cultural Experience

Tiered technical experience design: Two versions are offered for different age groups – a "Basic Version" (for middle-aged and elderly visitors) that simply scans a QR code to generate Tang-style photos, and an "Advanced Version" (for younger visitors) featuring AI-powered digital character interactions and immersive VR tours, thereby eliminating experience disparities caused by technical barriers.

Enhanced Cultural Experience: Incorporate "cultural micro-explanations" into existing performances (e.g., NPC explanations of Tang Dynasty merchant trade regulations or the symbolism of lantern patterns), complemented by a "Prosperous Tang Culture Handbook" (available upon scanning). This transforms "sensory immersion" into "cognitive immersion," deepening cultural value perception.

5.3. Service Upgrade: Addressing Pain Points in Consumption and Interaction

Enhanced consumption transparency and improved cost-effectiveness: Official accounts on TikTok and Xiaohongshu display prices for food and cultural products (e.g., Hu Bing is clearly priced at 25 yuan per piece), introduce combined tickets featuring "performances + cuisine" (offering a 20% discount compared to individual purchases), thereby alleviating tourists' concerns about spending;

Enhanced social engagement: Introduce "Tang Dynasty group games" (such as arrow-pushing and lantern riddles) and implement a "team check-in reward system" (where teams of three or more can redeem cultural-themed gifts); install "real-time crowd counting screens" throughout the neighborhood and recommend lesser-known attractions (e.g., the Hu Shang Museum) to alleviate congestion at popular sites.

6. CONCLUSION AND PROSPECTS

6.1. Research Conclusion

This study takes the Chang 'an Twelve Hours themed district as a typical case, collecting a total of 13,864 UGC texts from three major platforms—TikTok, Xiaohongshu, and Ctrip—to construct a dynamic evaluation framework for tourists' immersive experiences based on multi-platform UGC content. By integrating LDA topic mining, sentiment analysis, and multi-time-scale analysis, the study systematically reveals the core characteristics of tourists' immersive experiences, the patterns of emotional evolution, and their influencing factors. The main research conclusions are as follows:

(1) The core value of immersive experiences lies in two key dimensions: "cultural perception and technological interaction." LDA topic analysis identified five major experience themes, among which "interaction between Tang Dynasty-themed performances and NPCs," "AI/VR-powered intelligent interaction," and "scene and cultural authenticity" accounted for over 74% of the total, with significantly higher emotional scores than other themes, demonstrating that the deep integration of culture and technology is crucial for enhancing visitor immersion and satisfaction.

(2) Tourist experiences exhibit significant temporal fluctuations and event-driven responsiveness. During peak hours, weekends, and the tourist season, the proportion of negative reviews rises markedly while emotional scores decline, primarily due to service and environmental issues such as queue congestion and equipment malfunctions. In contrast, cultural events (e.g., the Tang Dynasty Lantern Festival) and technological upgrades (e.g., VR device updates) significantly enhance tourists' emotional experiences, demonstrating the positive role of event-driven factors in experience optimization.

(3) Multi-platform UGC data exhibit distinct platform-specific differences and user behavior characteristics. The TikTok platform hosts the largest volume of UGC (44.9%), emphasizing visual

presentation and real-time experience sharing; Xiaohongshu focuses primarily on in-depth text-based notes (34.9%); while Ctrip emphasizes comprehensive reviews (20.2%). The temporal distribution of data volumes closely aligns with holiday periods, reflecting the spatiotemporal sensitivity of UGC data.

(4) The application of smart technologies requires a balance between "immersion" and "user convenience." Research has demonstrated that excessive reliance on technological devices (e.g., AR/VR) may lead to experience disruptions due to issues such as queuing or malfunctions, highlighting the need for technical interventions to prioritize user experience fluidity and stability.

Based on these findings, this study proposes targeted strategies across three dimensions—smart operations, product optimization, and service enhancement—including developing a passenger flow early-warning model, implementing tiered technical experience design, strengthening cultural interpretation mechanisms, and improving consumption transparency—all aimed at continuously refining immersive experiences and fostering sustainable development of smart tourism scenarios.

6.2. Limitations and Future Prospects of the Study

6.2.1. Insufficient Research

Limitations of data sources and coverage: The current study solely relies on UGC texts from three major platforms—TikTok, Xiaohongshu, and Ctrip—and does not incorporate other high-traffic platforms such as Weibo and WeChat, nor offline interview data, which may lead to data bias. Additionally, the data period is limited to May 2023 to April 2025, failing to cover longer-term trends (e.g., the impact of cross-year cultural events), thereby restricting the comprehensiveness of the dynamic model.

Deficiencies in neutral text processing within sentiment analysis methods: Sentiment analysis fails to adequately distinguish the specific semantics of neutral texts. For example, terms like "many people" may represent objective descriptions (not negative experiences) in UGC but are often automatically classified as negative by models, resulting in an error rate of approximately 12% in sentiment scores. Similarly, culturally neutral terms (e.g., "Tang Dynasty architecture") lack contextual context integration, compromising assessment accuracy. These limitations stem from the algorithm's inadequate handling of unstructured data and absence of semantic disambiguation techniques.

6.2.2. Future Prospects

Future research could incorporate additional interview data and integrate "text + interview" analysis to deepen insights; simultaneously, the study framework can be applied to other immersive cultural tourism projects to validate the universality of the evaluation system. More advanced natural language processing models (such as BERT or emotion dictionary-enhanced analysis) may also be employed to identify implicit emotions and subtle attitude shifts in texts, particularly enhancing semantic deconstruction of neutral texts. Through these extensions, future studies can further enrich the theoretical framework for smart tourism and immersive experiences, providing more practical and forward-looking guidance for the intelligent and immersive development of cultural tourism projects.

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