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NEXTGENGUIDES: AI-ENHANCED MULTIMEDIA NAVIGATION AND CONTENT CREATION FOR CULTURAL HERITAGE

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ABSTRACT

Cultural heritage digitalization still faces challenges in scalable content creation, seamless indoor/outdoor navigation, and accessibility. NextGenGuides is an integrated multimedia platform combining AI-assisted content generation, precise 3D geo-localization, and sensory guidance for visually impaired users. Its human–AI collaborative framework ensures authentic, high-quality narratives, while a modular cloud architecture supports scalability and inclusion. The platform provides a holistic and sustainable solution for digital tourism and cultural heritage valorization.

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1. Introduction

The tourism and cultural heritage sectors are undergoing a profound digital transformation (Lazzeretti et al., 2025; Madzík et al., 2023), increasingly relying on virtual reality, mobile and wireless technologies to enhance visitor experiences and promote cultural assets. This shift is crucial for sustainable development and economic growth, particularly in regions possessing rich, yet often underexploited, cultural heritage. The rapid evolution of Artificial Intelligence (AI), especially Generative AI (Mallikarjuna & Chittemsetty, 2024), presents unprecedented opportunities to revolutionize content creation, personalization, and operational efficiency within these sectors. The integration of these digital technologies and AI in tourism (Florido-Benítez & del Alcázar Martínez, 2024), emphasizes the role of advanced solutions in real-world applications.

1.1. Problem Statement

Despite significant technological advancements, current digital tourism platforms face several challenges. Content creation is often a manual, time-consuming, and costly process, which hinders the rapid valorization of cultural assets. While AI offers automation, purely AI-generated content can sometimes lack emotional depth and trust-building elements, crucial for authentic cultural narratives. A persistent technical challenge lies in achieving accurate and seamless indoor-outdoor navigation (Sun et al., 2025), particularly within intricate cultural heritage sites like museums or archaeological areas where Global Navigation Satellite System (GNSS) signals are unreliable or unavailable. Existing solutions frequently suffer from variable infrastructure, signal interference, and complexities in sensor fusion, making consistent user guidance difficult. Furthermore, many digital experiences lack comprehensive accessibility features, thereby excluding visually impaired individuals and limiting their independent exploration of cultural sites. While various assistive technologies exist, their widespread acceptance and seamless integration into mainstream platforms remain low, highlighting a gap in truly inclusive design. These challenges underscore the pressing need for robust solutions that address these multifaceted issues, particularly in areas such as positioning, localization, and tracking.

1.2. Project Overview

The NextGenGuides project aims to develop an innovative multimedia platform and an integrated ecosystem of tools designed to comprehensively address these challenges. It seeks to empower tourist guides and cultural institutions by providing AI-assisted content generation that leverages the collective intelligence and domain knowledge distributed among qualified operators. This approach transforms dispersed individual expertise into structured, high-quality multimedia narratives. Combined with advanced geo-localized navigation, 3D modeling capabilities, and integrated accessibility features for visually impaired users, the platform fosters a sustainable and scalable framework for cultural heritage valorization, aligning with broader societal and policy objectives.

1.3. Key Contributions

The contributions of this work are multi-faceted and address key areas:

- A novel human-AI collaborative framework for multimedia content generation: This approach addresses the limitations of fully automated AI content by integrating expert human supervision, ensuring authenticity and quality while significantly reducing costs and time.
- An advanced, seamless indoor-outdoor geolocalization and navigation system: Designed specifically for complex cultural heritage environments, this system leverages accurate 3D maps and overcomes GNSS limitations, which is crucial for reliable location-based services.

- Integrated solutions for rapid 3D model generation and sensory guidance for visually impaired users: These features enhance immersive multimedia experiences and promote inclusivity within mobile applications. This feature is particularly relevant because it shows the platform's ability to deliver rich content to diverse users.
- A scalable, cloud-based platform architecture: Designed for high elasticity and modularity, this architecture can support a growing number of users and data volumes. This contributes to robust system design and mobile cloud computing, ensuring the platform's adaptability and performance.

The convergence of AI, advanced localization, and accessibility features within NextGenGuides represents a significant advancement beyond the fragmented and often siloed nature of current digital cultural heritage solutions. This integrated approach offers a more holistic and sustainable model for tourism, addressing both content generation and consumption challenges within a unified framework. This highlights that, while individual technologies exist, their synergistic combination into a comprehensive "ecosystem of tools" allows for a truly guided and personalized user journey that transcends mere information delivery.

2. Related Work

The landscape of digital tourism and cultural heritage valorization has seen significant advancements, yet persistent challenges remain. An examination of existing literature reveals distinct areas where NextGenGuides offers novel contributions.

2.1. AI in Digital Tourism and Content Generation

Generative AI is rapidly transforming the travel industry, offering capabilities such as personalized travel recommendations, dynamic pricing, 24/7 customer support via AI chatbots, and enhanced operational efficiency. AI agents can create personalized itineraries, recommending destinations, and providing real-time updates based on user preferences and historical data (Ilieva et al., 2024). Beyond textual content, AI can draft engaging articles about destinations and generate visual content for marketing campaigns (Zolanski & Borcea, 2024). Computer vision and AI algorithms are also being deployed for visitor behavior analysis, crowd management, and creating augmented reality (AR) experiences in museums (Trunfio et al., 2022), enhancing visitor engagement. However, a critical limitation of purely AI-generated is its potential lack of emotional depth and inability to build trust, especially as it becomes harder to distinguish from human-created work, raising fears about deepfakes, the spread of false information (Suri, 2024), and the displacement of artistic professionals whose narratives offer deeper emotional resonance and cultural insight. Additionally, personalization for infrequent travelers is often limited by the availability of sufficient individual data. Broader challenges for AI adoption in this sector include data privacy and security concerns, high implementation costs, ethical issues related to bias, and difficulties in integrating new AI systems with legacy IT infrastructures. Addressing these limitations within mobile and wireless network contexts is crucial for the widespread adoption of AI-driven tourism solutions. However, existing approaches largely treat AI as an isolated automation tool rather than part of a human–machine collaboration model. NextGenGuides advances this field by integrating expert-driven supervision into generative AI workflows, ensuring authenticity and emotional depth in cultural narratives.

2.2. 3D Modeling for Cultural Heritage

Global Positioning System (GPS) is highly effective for outdoor navigation but proves unreliable indoors due to signal obstruction, multipath effects, and variable infrastructure within buildings. Consequently, Indoor Positioning Systems (IPS) constitute a significant research area (Alkhawaja et al., 2019), with various technologies explored, including Wi-Fi, Bluetooth Low Energy (BLE) beacons, Ultra-Wideband (UWB), Infrared (IR), Ultrasound, Magnetic, Optical/Vision systems, and Pedestrian Dead Reckoning (PDR)/Inertial Navigation Systems (INS). Museums, by their nature,

present particularly challenging environments for IPS due to their dense object layouts, unique building materials, and the stringent requirement for high accuracy (e.g., +/- 25 cm) to provide exhibit-specific information. Despite numerous attempts (Aricò et al., 2023a; Aricò et al., 2023b; Aricò et al., 2024), no single prevailing technology has emerged that fully satisfies all requirements for seamless and accurate indoor navigation in such complex settings. Common challenges include the complexity of creating and maintaining accurate indoor maps, the integration of diverse sensors (sensor fusion), calibration, ongoing maintenance, and optimizing power consumption on mobile devices. Existing applications often combine GPS for outdoor segments with BLE beacons or numbered stations for indoor tours, offering features like offline use and multimedia content. Some also provide real-time updates and personalized recommendations. The development of robust and seamless indoor-outdoor localization systems is paramount for enhancing user experience in mobile and wireless networks. While prior research explores multiple positioning technologies, these remain fragmented and often context-specific. NextGenGuides introduces a unified indoor–outdoor localization approach explicitly designed for cultural sites, overcoming GNSS limitations and ensuring consistent spatial accuracy.

2.3. Mobile Navigation for Cultural Heritage

Three-dimensional (3D) modeling, particularly through photogrammetry, has found significant applications in the cultural heritage domain for documentation, restoration, conservation, presentation, and research (Barrile et al., 2017; Guidi et al., 2004; Remondino et al., 2009). Photogrammetry, an image-based 3D technology, is an accessible and cost-effective technique that processes 2D images from standard photographs into 3D data, making it practical for cultural heritage professionals. 3D models enhance the detailed interpretation of artifacts, allow for virtual exploration (e.g., virtual museums), and facilitate the sharing of archaeological data among experts. Despite these benefits, challenges persist, including the detailed documentation of complex 3D geometries and managing the large-scale data and computational requirements associated with high-fidelity models. The efficient generation and delivery of such rich 3D multimedia content are crucial for creating truly immersive experiences for mobile users. Unlike previous works focused mainly on static documentation, NextGenGuides integrates photogrammetric 3D modeling directly within a live platform for real-time multimedia generation and dissemination.

2.4. Extended and Virtual Reality for Cultural Heritage

Extended Reality (XR), encompassing Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), has emerged as a transformative technology for enhancing visitor engagement in cultural heritage contexts. XR applications provide immersive storytelling, interactive visualizations, and remote participation opportunities that traditional methods cannot achieve. Recent research in a previous project (i.e. Colosseum), demonstrates the potential of XR-based teleoperated tours, where remote guides can interact with visitors in real-time through low-latency multimedia streams, geolocation, and geofenced triggers within museums or heritage sites (Pacho Rodríguez et al., 2023). These systems integrate indoor positioning, real-time audio/video communication (e.g., via WebRTC), and AR/VR content generation to deliver contextual information tailored to user location and orientation. Furthermore, studies show that combining XR with AI-driven content personalization and 3D reconstruction can significantly increase user satisfaction and learning outcomes, while fostering inclusivity for remote and mobility-impaired audiences. Despite these advances, existing solutions often face challenges related to scalability, device heterogeneity, and the seamless integration of XR components with broader digital tourism ecosystems. Yet most XR implementations operate as standalone experiences without integration into broader tourism ecosystems. NextGenGuides bridges this gap by embedding XR components into an interconnected AI and localization framework, enhancing scalability and interoperability.

2.5. Accessible Tourism Technologies

Individuals with visual impairments or blindness (PwVIB) frequently encounter significant barriers in tourism, encompassing difficulties in accessing information, navigating physical environments, and ensuring personal safety. Accessible tourism aims to foster independence and inclusivity through specialized services and sensory engagement, recognizing that PwVIB experience the world through senses beyond sight. Assistive technologies (ATs), particularly smartphone applications, provide various solutions such as voice-activated GPS, real-time visual descriptions, and indoor navigation capabilities (e.g., Aira, Be My Eyes, OKO, Blind Square, Good Maps Outdoors, Seeing AI). The Blind Museum Tourer application (Meliones, 2018), for instance, enables high-precision autonomous indoor navigation for PwVIB in museum settings. However, despite these advancements, the overall acceptance of AT solutions remains low due to challenges in providing the right functionality, effectiveness, and usability for diverse needs. An interdisciplinary approach, combining computer science, design, and cognitive sciences, is necessary to overcome these hurdles and integrate accessibility seamlessly into mobile and wireless applications. Despite progress in assistive technologies, accessibility is often treated as an add-on rather than a core design element. NextGenGuides addresses this by embedding sensory guidance within the main navigation and content system, promoting true inclusivity.

2.6. Positioning NextGenGuides

NextGenGuides distinguishes itself by offering a uniquely integrated and comprehensive solution that addresses multiple critical gaps in the existing landscape of digital tourism and cultural heritage valorization. The platform's distinctiveness can be summarized in the following key areas:

- AI-Assisted Content Generation
    - Existing Solutions: Typically rely on purely automated processes, which often lack human nuance, emotional depth, and elements that build trust in the content.
    - NextGenGuides' Innovation: Employs a hybrid human-AI collaborative approach. AI tools assist human experts in rapidly generating professional and cost-effective multimedia content, ensuring authenticity and high quality.
- Seamless Indoor/Outdoor Localization
    - Existing Solutions: Often limited to outdoor GPS or fragmented indoor solutions (e.g., BLE beacons, Wi-Fi fingerprinting), facing challenges with signal interference, variable infrastructure, and transitions between environments.
    - NextGenGuides' Innovation: Provides integrated, precise indoor/outdoor navigation with accurate 3D maps. It is designed to overcome GNSS limitations and ensure seamless transitions in complex cultural sites.
- Integrated 3D Model Generation
    - Existing Solutions: Typically offer limited or external 3D integration, often relying on pre-generated models with static views.
    - NextGenGuides' Innovation: Features rapid photogrammetry-based 3D model generation directly within the platform, enabling dynamic creation of high-quality, interactive 3D assets.
- Dedicated Visually Impaired Guidance
    - Existing Solutions: Often depend on standalone assistive applications, frequently lacking deep integration with core tourism content and navigation.
    - NextGenGuides' Innovation: Incorporates embedded sensory guidance via mobile devices for full inclusivity, delivering alternative sensory suggestions (audio, maps) directly within the main platform.
- E-commerce/Marketplace for Expert Content
    - Existing Solutions: Generally, use standard e-commerce platforms not specialized for expert-generated multimedia content, or generic travel booking sites.

    - NextGenGuides' Innovation: Offers a specialized marketplace for expert-generated multimedia content (paid/free), fostering direct commercialization by guides and institutions.
- Community Co-creation Focus
    - Existing Solutions: Exhibit limited user-generated content, often informal (e.g., social media reviews), without a structured framework for expert co-creation.
    - NextGenGuides' Innovation: Provides a framework for co-generation of content by experts and the community, building a "network of interests and values" for next-generation tourism.

NextGenGuides' approach to content generation represents a significant advancement. Unlike purely automated AI content tools that can lack emotional depth and trust, NextGenGuides employs an "assisted generation" framework where AI/ML and Generative AI tools support human experts (tour guides, museum staff) in rapidly creating professional multimedia content. This supervised approach ensures content quality, authenticity, and cultural nuance, overcoming a key limitation of current AI applications in this domain. This hybrid model is particularly relevant, demonstrating how AI can augment human expertise in practical applications.

The platform's seamless and accurate indoor-outdoor geo-localization with 3D maps is another distinguishing feature. While various indoor positioning systems exist, NextGenGuides specifically studies and integrates hardware and software solutions for "localization and navigation oriented to content consumption" for both indoor and outdoor environments, explicitly requiring "accurate 3D maps" and designed to function where GNSS is insufficient. This goes beyond generic navigation apps or fragmented indoor solutions by aiming for a truly seamless transition and high accuracy within complex cultural sites, directly contributing to the "Positioning localization and tracking" theme in mobile networking.

Furthermore, NextGenGuides integrates automated guidance for visually impaired individuals directly into its core platform, rather than relying on standalone assistive applications. This includes delivering alternative sensory suggestions (audio, maps, etc.) via mobile devices and headphones. This provides a more embedded and holistic accessibility-centered experience from the ground up, fostering greater independence and inclusiveness. This inclusive design paradigm is a vital application of services over wireless and mobile networks.

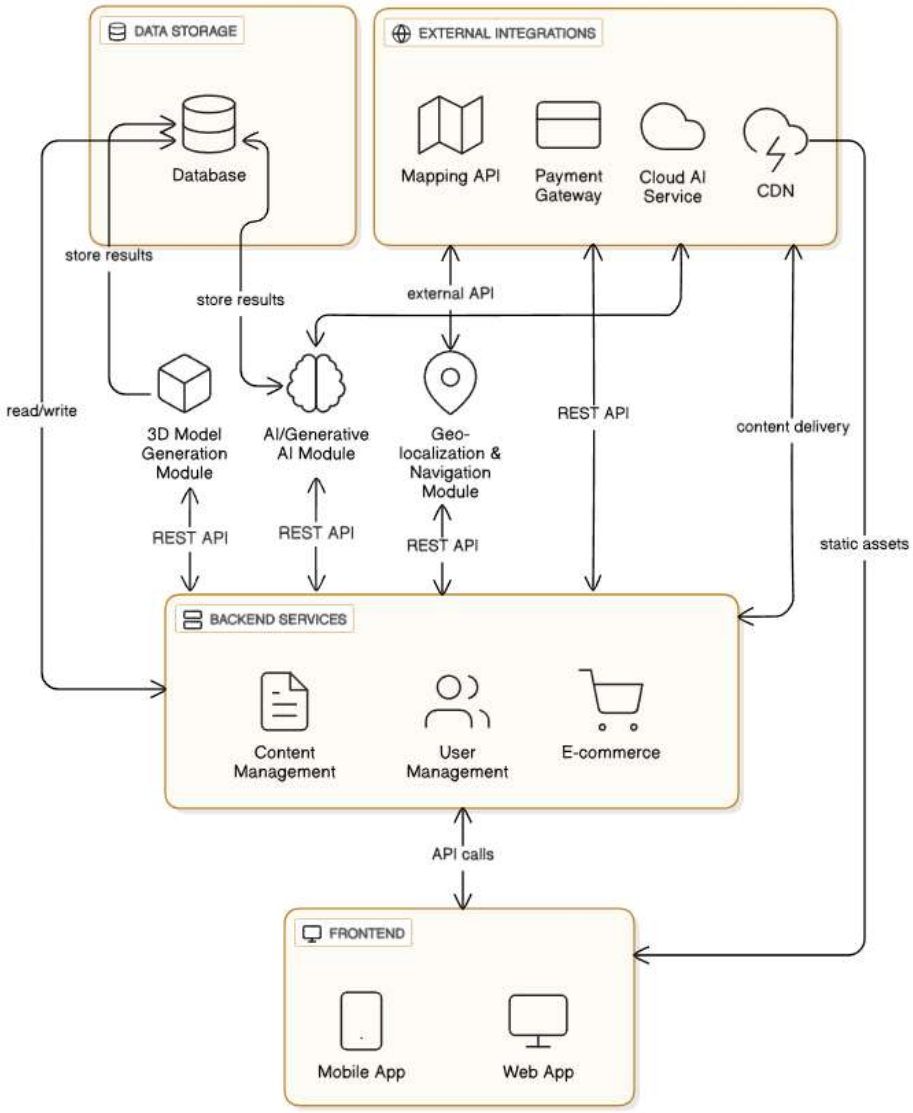
Beyond individual technical features, NextGenGuides proposes a comprehensive ecosystem featuring an integrated e-commerce marketplace and a co-creation framework. This fosters a "network of interests and values" for the next-generation tourism sector, enabling professionals to commercialize content and promoting local economies. This broader impact, not typically found in purely technical or content-delivery platforms, demonstrates a holistic approach to digital tourism that aligns with interests in network economics and platform design.

3. Methodology and System Design

3.1. Overall System Architecture

The NextGenGuides platform is engineered on cloud-based, modular, and scalable architecture as shown in Figure 1, to dynamically support a growing number of users and increasing data volumes, ensuring optimal performance and continuous service availability.

Figure 1. Overall platform architecture. Shows data flow between Frontend, Backend Services, AI/3D Modules, Geo-localization, and External Integrations using REST APIs and shared storage.



Source: Own elaboration, 2025.

3.2. AI/Generative AI Framework for Content Creation

A core component of the NextGenGuides platform is its proprietary framework designed for the "assisted creation of multimedia content and guided, geolocated tourist routes". This framework harnesses advanced AI/ML and Generative AI tools, enabling operators, guides, and museum experts to rapidly generate "effective and professional content" in an integrated way that is indistinguishable from manually produced content and at a much lower cost. The system will leverage external cloud services to access and utilize advanced AI models, ensuring access to cutting-edge capabilities.

3.3. Advanced Geo-localization and Navigation System

The project includes implementing both indoor and outdoor route tracking and navigation systems, requiring accurate 3D maps. This approach is particularly critical in environments where traditional satellite navigation (GNSS) is inaccurate or non-functional, such as within complex museum interiors or densely built urban areas. The system's objective is to assist users in

seamlessly transitioning between indoor and outdoor cultural sites, relying on precise location data delivered over wireless channels.

3.4. 3D Model Generation

NextGenGuides will investigate solutions for the rapid generation of 3D models of artworks, sites of interest and multimedia models, based on photogrammetry. This capability enables the creation of high-quality 3D representations of cultural assets, which are essential for delivering immersive digital experiences to users. The efficient generation and subsequent delivery of these complex 3D multimedia content over wireless networks are crucial for enhancing wireless multimedia networking capabilities within the platform.

3.5. Sensory Guidance System for Visually Impaired Users

A unique and inclusive aspect of the project is the study of solutions for the automatic guidance of blind and visually impaired people. This involves guiding users through alternative sensory suggestions (audio, maps, etc.) that will be conveyed through mobile devices, headsets or other systems. Our system is designed to integrate directly with the mobile application's primary navigation features, ensuring that accessibility is a foundational element rather than an add-on.

3.6. Validation and Pilot Testing Strategy

To address the need for rigorous practical applicability and to mitigate the limitations identified regarding the lack of empirical results, a structured two-phase validation strategy will be implemented.

3.6.1. Phase 1: Technical and Feasibility Validation

This phase focuses on ensuring the core technological components of the platform are robust, scalable, and meet performance benchmarks.

- Geo-localization Accuracy Testing: Conduct controlled field tests in a complex cultural heritage site (e.g., a multi-story museum or archaeological ruin). The primary metric will be the localization error (in cm) for both indoor-only and seamless indoor/outdoor transitions, explicitly comparing the system's performance against standard GNSS-only applications where available. The target accuracy for exhibit-specific information will be ±25 cm.
- Performance and Scalability Analysis: Evaluate the cloud-based architecture's elasticity by simulating a high volume of concurrent users and data transactions. Metrics will include network latency, API response time, and power consumption on mobile devices during content streaming and real-time localization.
- Content Generation Efficiency: Quantify the efficiency gains of the human-AI collaborative framework. This will include a comparative analysis of time and cost between generating a standardized multimedia tour (e.g., 5 points of interest) manually versus using AI-assisted tools.

3.6.2. Phase 2: User Experience and Inclusivity Validation

This phase is dedicated to assessing the practical effectiveness, usability, and social impact of the platform with end-users.

- Usability Studies (UX): Conduct targeted trials with two key user groups: professional tour guides/museum staff (operators) and general tourists (consumers). Feedback will be collected on the Content Management System (CMS) workflow, the intuitiveness of the mobile application interface, and overall user satisfaction (SUS score).
- Inclusivity and Accessibility Evaluation: Perform specialized testing with visually impaired individuals using the sensory guidance system. Evaluation will focus on the

effectiveness of non-visual navigation cues, the clarity of alternative sensory suggestions, and the overall fostering of independence and inclusivity during cultural exploration.

- Content Authenticity and Trust: Conduct qualitative studies (interviews/surveys) to assess users' perception of the authenticity, emotional depth, and trustworthiness of content generated through the human-AI collaborative framework, addressing a key limitation of purely automated AI content.

4. Results & Discussion

The NextGenGuides project has undergone preliminary tests with a restricted group of business users, confirming the technical and business feasibility of its commercialization aspect. Informal but positive feedback has been received from various potential users and beneficiaries, including museum directors, expert tourist guides, and specialists in cultural heritage conservation, validating the market need and initial concept. Pilot content, including geo-localized multimedia such as podcasts, has been successfully generated and distributed for demonstration and testing purposes, showcasing the platform's content delivery capabilities. The efficiency gains anticipated from the AI-assisted content generation framework are expected to be substantial, enabling the rapid production of high-quality, professional content at significantly reduced costs, which is a key objective for scaling content valorization. Initial tests of the geo-localization solutions in relevant environments are expected to demonstrate improved accuracy, particularly in challenging indoor/outdoor transitions, fulfilling a critical technical requirement for seamless user experience.

NextGenGuides is expected to deliver several significant contributions and impacts across the digital tourism and cultural heritage sectors. The platform will provide enhanced user experience, offering immersive and personalized journeys that enrich tourists' engagement with cultural heritage through high-quality multimedia content and seamless navigation. By creating a dedicated e-commerce marketplace for guides and experts, NextGenGuides will stimulate the tourism sector, enabling new revenue streams and fostering a vibrant "network of interests and values" for the next-generation tourism industry. A crucial contribution lies in the promotion of sustainable tourism. By enabling digital guides and content co-generation, the project supports "green" and "sustainable" tourism models.

From a technological standpoint, the project significantly advances ICT innovation, pushing AI-driven content platforms, advanced localization systems, and accessible mobile applications to higher levels. The modular, cloud-based architecture ensures high scalability and replicability, allowing the solution to be deployed across various tourism contexts (cities, regions, countries) and even adapted for other sectors such as education, industry, and healthcare.

The project's emphasis on "co-generation of contents" and "onboarding of initial beneficiaries with subsidized or free licenses" suggests a community-driven, platform-as-a-service (PaaS) model for cultural content creation. This moves beyond traditional top-down content delivery to a more decentralized and collaborative ecosystem. This approach is particularly relevant, as it can lead to a more diverse, authentic, and rapidly expanding content library, reducing the burden on a central team and potentially fostering a more resilient and adaptable tourism content economy.

5. Conclusion

This paper presented NextGenGuides, an innovative multimedia platform poised to revolutionize digital cultural tourism through the strategic integration of advanced technologies. While it primarily establishes the innovative design, system architecture, and technical feasibility of the platform, the absence of large-scale empirical results is acknowledged. The immediate focus has been on developing a comprehensive, integrated solution that addresses fragmented challenges in the digital heritage landscape, with a novel human-AI collaborative framework for scalable and authentic content generation, an advanced and seamless indoor-outdoor geo-localization system specifically tailored for complex cultural sites, and an integrated sensory guidance solution

ensuring comprehensive accessibility for visually impaired users. This directly addresses key critical challenges and opportunities within AI-based tools for networking, positioning localization and tracking.

Future work will primarily focus on expanding the real-world deployment and rigorous validation of the NextGenGuides platform. This includes further refinement of AI models for content generation based on user feedback and large-scale data and optimizing geo-localization algorithms for even higher precision and robustness across diverse and challenging environments.

A significant area of future exploration involves integrating with emerging wireless technologies such as 5G/6G enhancements. These advancements are expected to enable ultra-low latency multimedia streaming and significantly enhanced localization accuracy, which will further improve the immersive user experience. Additionally, the potential for edge computing will be investigated to enable more responsive, on-device AI processing and real-time content adaptation, reducing reliance on centralized cloud resources and improving overall system performance.

Further research will also investigate novel sensory feedback mechanisms and personalized multi-sensory experiences for visually impaired users, potentially leveraging haptic feedback for navigation and augmented audio realities to create even richer, more inclusive interactions. Finally, comprehensive performance evaluation in large-scale deployments will be conducted to assess system scalability, network latency, and power consumption on mobile devices, ensuring the platform's long-term viability and efficiency.

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