AI-Driven Personalization in Tourism: Enhancing Visitor Experiences Through Real-Time Data

Ioannis Deliyannis[1,*,†], Ioanna Afroditi Mazi[2,†], Sofia Maria Poulimenou[3,†], Despina Elisabeth Filippidou[4†], Eleni Christodoulopoulou[5†], Anastasios Manos[6†], Minas Pergantis[7,†]

[1] Ionian University, Department of Audio and Visual Arts, Corfu, Greece

[2] Ionian University, Department of Audio and Visual Arts, Corfu, Greece

[3] Ionian University, Department of Tourism, Corfu, Greece

[4] Dotsoft S.A., Athens Greece

[5] Ionian University, inArts Research Laboratory, Corfu, Greece

[6] Dotsoft S.A., Athens Greece

[7] Ionian University, Department of Audio and Visual Arts, Corfu, Greece

Abstract

The widespread use of big data in several aspects of social sciences, has found application in the tourism industry, especially in enabling deeper insights into travelers' behaviors and preferences. The analysis of large datasets, assists tourism stakeholders to optimize resources and meet the expectations of visitors, with personalization. The INDIANA Project introduces an innovative platform that utilizes artificial intelligence (AI) and big data to transform the tourism experience through highly personalized, real-time recommendations. This platform integrates data from multiple sources, including recommendation systems, cultural organizations, tourism-related businesses and users, to provide visitors with tailored suggestions based on their preferences and real-time conditions such as location, weather, and activity level. Central to the system is the concept of a "Digital Twin," an anonymous profile that reflects the traveler's demographics and behaviors, updated through IoT devices like smartphones and wearables. This allows the platform to offer dynamic, AI-driven recommendations while respecting user privacy. The platform further enhances user interaction through augmented reality (AR), push notifications and an adaptive reasoning system that takes into account the changes that occur on a daily basis, locally, delivering immersive experiences and timely content. With its advanced segmentation of tourist typologies, the system supports targeted recommendations, helping visitors explore lesser-known areas, thereby contributing to the sustainability of tourism by reducing overcrowding at popular destinations. Additionally, INDIANA enables local businesses and cultural organizations to gain valuable insights from visitor data, refining their offerings to align with evolving traveler behaviors. Developed through a collaboration between Ionian University and DOTSOFT S.A. and funded by the European Union, the project represents a significant step forward in integrating technology with tourism, combining personalization, sustainability, and economic development for a comprehensive enhancement of the visitor experience.

Keywords

AI in tourism; Big data analytics; Personalized travel; Digital twin; Smart tourism; Augmented reality in tourism

1. Introduction

The use of recommendation systems in tourism has changed the way travelers engage with destinations by offering personalized suggestions for activities and visits. These recommendation systems often rely on a combination of big data and artificial intelligence (AI) as they gather and analyze vast amounts of data, including traveler preferences, behaviors, real-time location, and

environmental factors, to create customized itineraries and experiences. Through the application of machine learning and AI, recommendation systems can continuously refine suggestions by adapting to the evolving preferences of tourists, offering a dynamic and personalized user experience [1]. Big data plays a fundamental role in the quick processing of diverse inputs, such as user reviews, trends, real time weather and traffic situations, ensuring timely and relevant recommendations for users [2,3]. Furthermore, the optimization of visitor distribution by these systems, can support sustainable tourism, prevent overcrowding at popular sites and promote lesser-known attractions [4]. The combination of AI and big data in tourism recommendation systems enhances user satisfaction while fostering a deeper connection with local cultures and destinations [5].

This research focuses on the above-mentioned aspects in the creation of an innovative tourism recommendation system, based on AI and Big Data. This system is designed in the framework of a European co-funded project, named "Indiana: Intelligent Management System". The INDIANA project involves the research, design, and development of an innovative platform that disseminates tourist and cultural Points of Interest (POIs) to travelers, on a highly personalized level, with the use of state-of-the-art technologies, Big Data and Artificial Intelligence. The type of service it will provide, is a recommendation system that considers the traveler's profile, personalized requirements, position, disposition, and real-time conditions. The users of this innovative service are mainly travelers and professionals in the tourism and cultural field. Users will aid the design and dissemination of personalized services, aiming to create on-demand service for travelers, in the form of a "Digital Twin". This will be implemented via the design and deployment of a travelers' data repository consisting of demographics, physical and expert activities, number of participants, and their current location, which will then form specific clauses or "expert rules".

Innovation lies in the deployment of AI technologies for achieving a higher standard of personalization in tourist recommendation systems, through real-time data and big data analysis and customization of recommendations. Overall, the project aims to disseminate tourist and cultural information and services as an added value to travelers and establish the personalization of services as a brand for professionals to attract travelers more successfully. The innovative final product will be up for immediate commercial exploitation. Last but not least, a crucial aspect of this project's implementation is the integration of Information Technologies with Tourism, Culture, and Creative Industries, as well as the spread of technical expertise and technology from research institutions to businesses.

2. Methodology

There are six phases during the implementation of the INDIANA project, each involving different work packages, distributed between researchers from the Ionian University (IU) and the collaborating company named "DOTSOFT S.A.". The first phase aims to define the requirements for the functions of the system as a whole and to integrate them into the architecture, in conjunction with the development of the technical specifications/standards of the platform. The requirements analysis report, describing the non-functional and functional requirements of potential users, a description, and the UML diagrams of usage scenarios, will be implemented by the IU. In this stage, DOTSOFT S.A. will be involved in the report on the system's architecture.

In the second phase, the infrastructure for data storage will be centered around a Data Hub and ETL tools will be developed and utilized for data transformation and integration into the Data Hub. Additionally, a curated repository of expert recommendations will be maintained to enrich the system's recommendation capabilities. The company is responsible for the implementation of this stage.

The third phase aims to collect models of the traveler's tourist experience, analyze them into parameters, and match them to data-expert activities. To capture the result of the "matching" between the traveler's behavioral model and the categories of information and services provided by professionals in the tourism-culture industry, a set of indicators will be designed regarding the

traveler's "Quality of Destination Experience". These indicators will allow the system's feedback on the traveler's satisfaction regarding the added value of the tourist experience provided and the "feedback" of the business models.

The next phase shared between the IU and the company is to develop code for creating a pervasive data-collecting platform and to create augmented (AR) tourist experience recommendations for travelers.

During the fifth phase, collaborators work towards the integration and test application of the recommendation system. A test operation and a pilot application of the platform on real data will be carried out, to confirm the added value to the tourist and cultural experience of the traveler, as well as debug. Also, publications deriving from previous research conducted throughout the phases will serve as publicity for the project.

Lastly, in the sixth phase, an economic impact assessment will be conducted, by examining relevant economic indicators to gauge the influence of the metasearch engine on the tourism industry, thereby closing the feedback loop for iterative enhancement of the final product.

It is deemed suitable to commence the procedure from the third stage, as a review and assessment of existing business models of tourism recommendation systems could be used as a guide and may indicate gaps that the INDIANA project could strive to fill.

This analysis aims to record and categorize the most widespread Business Models in the field of information and service provision to travelers so as to showcase the gaps that exist in the market. The ultimate goal of the research was not only to map existing business models of the traveler's tourism experience, but mainly to analyze them into parameters, and match them to data – expert activities. The result of the "matching" between the traveler's behavioral model and the categories of information and services provided by professionals in the tourism and cultural sector, a set of indicators related to the "Quality of Destination Experience" of the traveler will be designed. These indicators are tailored to measure traveler satisfaction in a tourism context, assessing added value and the perceived quality of experiences. By measuring satisfaction metrics directly linked to tourism outcomes (e.g., enjoyment, cultural enrichment, convenience), the system's effectiveness can be evaluated with respect to its impact on the traveler's destination experience. Most recommendation systems assess their effectiveness through standard machine learning metrics while the INDIANA platform is moving beyond conventional metrics, focusing on specialization of indicators to target the "Quality of Destination Experience". These indicators will allow for the feedback of the system with the traveler's satisfaction regarding the added value of the tourism experience provided to them and the "feedback" of the business models.

3. Reviewing the Business Models of Selected Tourism Recommendation Systems

Our initial investigation into actual recommendation systems, designed to be used by travelers, provides a comprehensive overview of various business models in the travel and tourism industry, focusing on different types of businesses and their operational features. For this scope, we gathered the most frequently mentioned recommendation systems in travel sites by searching for various business models and their alternatives. We based the research on key concepts such as context awareness, social media, IoT and augmented reality, big data and user modelling [6]. Sentiment analysis had also been suggested during the clustering procedure, in order to rank attractions according to the user's preferences as well as contextual information [7]. Conducting this research and clustering was important to pinpoint different provided services among popular internet sites like Trip Advisor, Booking, Airbnb, etc. The conceptual model took into consideration the above future aspects such as visitor profiles, services repository, big data mining, and trip planner items [8].

As business models tend to adapt to emerging technology advancements, several travel sites previously functioning as online travel agencies, like Booking, enrich their services by providing tours and activity packages. Subsequently, it became crucial to map the various services several

travel sites provide, to be able to detect possible gaps in their operational functions and general service. The list of systems is selected below based on their search engine popularity (Google search on tourist recommendation systems) and a review on forums regarding highly recommended systems.

The list was then enriched by identifying and listing their main business model, which helps us categorize systems into several types, such as tour/activity marketplaces, Online Travel Agencies (OTAs), experience providers, and digital nomad-related services.

- Airbnb Experiences - Tour/Activity Marketplace
- Booking - Online Travel Agency (OTA)
- Culture Trip - Experience
- Digital Nomad World - Digital Nomad Review (DN-REVIEW)
- Eventbrite - Tour/Activity Marketplace
- Expedia - Online Travel Agency (OTA)
- GetYourGuide - Tour/Activity Marketplace
- Google Travel - Search
- Kayak - Metasearch
- Live like local (Paros Antiparos) - Experience
- Live the World - Experience
- Nomad List - Digital Nomad Review (DN-REVIEW)
- ToursByLocals - Tour/Activity Marketplace
- Trip Advisor - Metasearch
- Trip Canvas (AAA Travel) - Experience + Tour/Activity Marketplace
- Tripit - Planner
- Viator (TripAdvisor) - Tour/Activity Marketplace
- Wanderlog - Experience
- WithLocals - Tour/Activity Marketplace
- Yelp – Metasearch

The data is structured using a spreadsheet to list each business using several criteria, including its global reach, whether it offers free services, and if it includes features like AI assistance, accommodation/travel booking, itinerary planning, ready-made itineraries, simple activity suggestions, tour orientation, local activities, reviews/ratings, smart functions (e.g., push notifications, weather updates, chat), and discovery tools.
Beyond business types, the other key insights from our research data include the following:

- Global Reach: Companies are classified based on their operational scope—either global (G), global with limitations (GL), or local (L). Most listed businesses have a global presence.
- Service Offering: The document identifies whether the services are free and if they offer AI assistant features. Most services are not free, and AI assistance is not commonly mentioned, indicating a potential area for innovation.
- Operational Features: It highlights various operational features, including accommodation/travel booking capabilities, itinerary planning, ready itineraries, activity suggestions, a focus on tours, local activities, and the presence of reviews/ratings. These features suggest the businesses' efforts to cater to diverse traveler needs, from accommodation to activity planning.
- Smart Functions and Discovery: Few businesses currently utilize smart functions or discovery tools, pointing to an area where the travel industry could further integrate technology to enhance customer experience.

This summary reflects the current landscape of business models in the tourism sector, emphasizing the diversity of services available to modern travelers and the opportunities for incorporating advanced technologies to improve the travel experience. Current research on business models in tourism is mostly taxonomical focusing on different variations [9]. At the same time, the use of technology for data analysis may transform service provision and value proposition through the exchange of resources such as user experience and culture [10].

Within the INDIANA project, the preference for using artificial intelligence (AI) as a processor over traditional approaches is driven by several compelling advantages. AI's ability to analyze vast datasets dynamically allows for the personalization of tourist experiences at an unprecedented scale and depth. Unlike traditional methods, which often rely on static, one-size-fits-all recommendations, AI can adapt to the evolving preferences and behaviors of each user, ensuring that the cultural and tourist recommendations are not only relevant but also timely and context-aware. This adaptability extends to real-time adjustments based on a variety of factors, including location, weather, and the current density of visitors at points of interest, optimizing the visitor experience while aiding in sustainable tourism management. Moreover, AI's predictive capabilities enable the platform to forecast trends and preferences, facilitating more effective planning and resource allocation for tourism operators. In essence, the use of AI as a processor within the INDIANA project represents a paradigm shift towards more intelligent, responsive, and personalized tourism and cultural exploration, harnessing the power of technology to enrich cultural experiences in a way that traditional methods cannot match. The next section describes the investigation implemented by the INDIANA system designers to provide a new service that collects all the important functionalities for the intended purpose.

4. System Design and Implementation

The INDIANA project is designed to be an innovative platform for disseminating tourist and cultural points of interest to travelers on a personalized level, employing a blend of contemporary technologies. Its structure and functions are described below:

Innovative Dissemination Platform: At its core, INDIANA aims to merge modern technologies to create a user-centric platform for tourists and cultural enthusiasts. This platform will recommend cultural and tourist sites based on user profiles, their current location, and their mood or disposition at the moment.

User Profiles: Travelers and experts (in tourism/culture) will link to profiles that can be enriched with basic demographic details, languages of communication, and types of experiences they are interested in. This personalized approach is informed by the research into operational models, emphasizing customization in service delivery, while preserving the privacy level that is imperative to be retained within recommendation applications.

Data Repository: Key components include:
- Demographic Data: Basic information about the traveler, like age and preferred language.
- Current Location: Utilizing GPS sensors to determine the traveler's location within a tourist area.
- Physical Activities: Information on the traveler's current activities, such as walking, running, swimming, etc.
- Expert Activities: Details on activities relevant to the traveler's purpose at a location, like shopping or eating.
- Companionship: Information on whether the traveler is alone, with friends, or with family, forming a digital twin of the visitor's experience.

Mobile Application Features:
- Push Notifications: For timely recommendations and alerts.
- Augmented Reality Content: Offering on-demand, immersive experiences of tourist spots.

- IoT Integration: To monitor and manage the flow of visitors at points of interest, aiding in crowd management and enhancing visitor experience.

Research and Community Engagement:

- Stakeholder Involvement: Engaging public sector bodies and businesses in the tourism and cultural sectors, particularly in Corfu, to recognize project benefits and bolster its applicability. This involves collaboration with tourist offices and enterprises, leveraging their expertise and insights.
- Dissemination and Development: The project plans to share its findings with the scientific community and stakeholders through publications, virtual workshops, social media announcements, and articles aimed at the commercial and business community.
- Corporate Identity and Outreach:
  - ✓ Development of a brand identity, bilingual website, and social media presence.
  - ✓ Promotion of the project through partners' communication channels, MOOCs, virtual and physical workshops (Living labs), and informative signage at key locations.
  - ✓ Utilization of QR codes for easy app downloads.
  - ✓ Organization of an information week in Corfu to introduce the program to students, residents, and visitors through open presentations, work meetings, and distribution of printed and digital materials designed for this purpose.

Connecting those characteristics to the previous research on business models, the INDIANA project aims to adopt a highly personalized approach to travel and cultural experiences, leveraging data analytics, IoT, and augmented reality. This approach aligns with trends in the tourism sector towards more customized, interactive, and sustainable experiences, showcasing a shift from traditional one-size-fits-all models to dynamic, user-centered platforms.

5. Results & Discussion

When contrasted with other existing systems, as described before, several key differences and advancements become evident:

- ✓ Personalization and User Profiles

INDIANA Project: Prioritizes deep personalization based on dynamic user profiles, which include not just demographic information but also real-time data on physical activities, location, and the traveler's current mood or companions. This level of customization goes beyond basic preferences to adapt recommendations in real time.

Other Systems: Generally offer personalization mainly based on static user preferences and historical data. They may lack the capability to adjust recommendations based on real-time physical activity or the specific context of the user's current situation.

- ✓ Integration of Modern Technologies

INDIANA Project: Integrates a wide range of contemporary technologies, such as IoT for crowd management and augmented reality for on-demand content, offering a more immersive and informed tourism experience.

Other Systems: While they might utilize AI for recommendations and have mobile applications, the integration of IoT and AR is not as prevalent, limiting their ability to offer real-time, context-aware content and manage visitor flow effectively.

- ✓ Stakeholder Engagement and Community Involvement

INDIANA Project: Involves a broad spectrum of stakeholders from the outset, including public sector bodies, local businesses, and the wider community in Corfu. This approach aims to ensure the project's benefits are maximized for all involved, from tourists to local service providers.

Other Systems: They may primarily focus on the end-user experience without a similar level of engagement with the broader ecosystem of stakeholders in the tourism and cultural sectors, potentially limiting their impact and sustainability.

✓ Educational and Dissemination Activities

INDIANA Project: Plans for extensive dissemination and educational activities, including virtual workshops, social media campaigns, and open information sessions for locals and visitors in Corfu. This comprehensive outreach is designed to foster community support and awareness.

Other Systems: Typically focus on user acquisition and marketing rather than community education and engagement, which may not build as strong a foundation for long-term adoption and support within the local context.

✓ Crowd Management

INDIANA Project: Utilizes IoT technologies to monitor and manage the number of visitors at points of interest, enhancing the visitor experience by preventing overcrowding and ensuring sustainability.

Other Systems: Often lack real-time crowd management capabilities, which can lead to issues with overcrowding at popular tourist sites, detracting from the visitor experience and posing challenges to sustainable tourism.

6. Conclusion and Future Work

The INDIANA project represents an important advancement in the tourism and cultural sector, integrating state-of-the-art technological features, supported by the synthesis of contemporary innovations and personalized user engagement. Initial key findings from the project design and implementation, accent the potential of such technological integrations to the significant enhancement of the quality and sustainability of cultural experiences for tourists. The use of visitor profiling, leverages data analytics and user preferences, enabling the platform to customize experiences for each visitor, ensuring that they receive content that is engaging to them. On the other hand, the use of augmented reality (AR) and Internet of Things (IoT) technologies, in particular, has demonstrated the capacity to encompass even more immersive, tailored, and engaging content. AR allows visitors to overlay digital information onto the physical world, providing them with a substantial understanding of their visiting surroundings. Meanwhile, IoT technologies enable real-time data collection and analysis, allowing for dynamic content adaptation and effective crowd management. As far as the latter is concerned, the platform may assist stakeholders in mitigating over-tourism and minimizing the negative impacts at a destination.

Reflecting on the project's contributions, INDIANA sets a new benchmark for how tourism and cultural heritage can be experienced in the digital age. It offers a blueprint for future innovations in the sector, highlighting the importance of personalization, technological integration, and stakeholder engagement. The role of personalization has been outlined by many researchers in the past years [11, 12, 13, 14], but the Indiana project elaborates even more and presents the ability for constant customization and proposal modifications, using AI algorithms.

The main innovation lies in the use of state-of-the-art technologies and the design of the system can be adapted without major restructuring, according to future input in the field. Furthermore, the project underlines the value of real-time data analytics in enhancing visitor experiences and operational efficiency. Potential areas for future research could explore the scalability of such platforms across different cultural contexts and their impact on local economies and community

engagement. Additionally, investigating the long-term effects of personalized tourism experiences on cultural heritage preservation presents an important aspect for exploration.

For the further development and deployment of the INDIANA platform, several considerations emerge. Firstly, the scalability and adaptability of the technology to different cultural and geographical contexts are paramount. This involves all kinds of technical aspects but also the customization of content to respect and highlight the unique details of each destination's heritage. Customization and personal recommendation are relevant to the users' needs but at the same time respect the unique characteristics of each destination. Secondly, ongoing engagement with and feedback from all stakeholders—including tourists, local communities, and the public and private sectors—is essential to refine and enhance the platform's offerings. Finally, addressing privacy and data security concerns will be crucial in maintaining user trust and compliance with global data protection regulations. The continued evolution of the INDIANA platform should aim not only to leverage emerging technologies but also to foster an inclusive, sustainable, and enriching tourism experience that benefits all stakeholders involved.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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