**Intelligent Applications and Practical Research of GPT-4o in Self-Guided Tour Route Planning**

**Abstract**

The rapid evolution of Artificial Intelligence (AI) has significantly transformed the tourism industry, particularly in self-guided tour planning. This study explores the application of GPT-4o, an advanced AI model, in designing intelligent and adaptive travel itineraries. Traditional itinerary planning faces several challenges, including time-consuming research, lack of flexibility, and overwhelming information overload. AI-powered solutions, particularly GPT-4o, offer a transformative alternative by integrating real-time data analysis, multimodal processing, and personalized recommendations to enhance self-guided travel experiences.

This paper presents a comprehensive methodology for AI-driven itinerary generation, detailing the integration of GPT-4o with travel APIs (Google Maps, OpenStreetMap, Booking.com, and real-time transport data) to optimize route planning dynamically. A case study in Kyoto, Japan was conducted, comparing AI-generated itineraries with human-crafted travel plans across four distinct traveler personas: budget traveler, cultural explorer, food enthusiast, and adventure seeker. The results highlight GPT-4o’s efficiency, adaptability, and personalization capabilities, while also acknowledging limitations in local cultural insights and spontaneous human decision-making.

Future prospects of AI-driven tourism are explored, including the integration of AR/VR previews, smart city applications, and AI-based crowd management to enhance sustainable tourism practices. Ethical concerns, such as data privacy, algorithmic biases, and AI’s impact on travel spontaneity, are also discussed. The findings indicate that GPT-4o significantly improves travel planning efficiency and adaptability, positioning AI as a cornerstone for the next generation of smart tourism.

**Keywords:** GPT-4o, AI in Tourism, Self-Guided Travel, Smart Itinerary Planning, AI-Powered Route Optimization

**1. Introduction**

**1.1 Background and Motivation**

In the aftermath of the COVID-19 pandemic, global tourism has undergone a paradigm shift, with an increasing number of travelers opting for self-guided tours over traditional guided packages (Gössling, Scott, & Hall, 2021) [1]. The pandemic highlighted the importance of personalized and flexible travel planning, as travelers sought to minimize health risks while maximizing the quality of their experiences. According to a report by the World Tourism Organization (UNWTO, 2023) [2], over 65% of post-pandemic travelers now prefer self-guided tours, compared to 42% before 2019, reflecting a growing demand for independent, tailored travel experiences.

However, planning a self-guided tour remains a complex and often overwhelming task due to several key challenges:

1. Time-Consuming Process - Travelers must sift through vast amounts of information from travel websites, blogs, and reviews to craft a well-structured itinerary. Research shows that, on average, independent travelers spend between 5 and 10 hours planning their trips, with many finding the process daunting (Li et al., 2022) [3].
2. Lack of Flexibility in Pre-Planned Itineraries - Conventional itinerary planning tools, such as static travel guides or fixed-route tour packages, fail to accommodate real-time changes, such as sudden weather shifts, transport disruptions, or personal schedule adjustments (Higgins-Desbiolles, 2021) [4].
3. Information Overload and Decision Fatigue - With the proliferation of online travel platforms, travelers often struggle to filter relevant information from excessive content. A recent study found that 72% of travelers experience decision fatigue due to conflicting recommendations from multiple sources (Fennell, 2021) [5].

Given these challenges, Artificial Intelligence (AI) has emerged as a transformative force in travel planning. AI-driven tools, particularly those leveraging large language models (LLMs) like GPT-4o, have the potential to streamline itinerary planning, optimize route efficiency, and enhance overall travel experiences. By utilizing real-time data analysis, AI can provide personalized, flexible, and adaptive travel plans tailored to individual needs (Xie & Zou, 2024) [6].

**1.2 Research Significance**

The integration of AI into self-guided travel planning is not merely a convenience but a necessary innovation in modern tourism (Javadinasr et al., 2024) [7]. GPT-4o, a state-of-the-art multimodal AI model, offers several distinctive capabilities that position it as a valuable tool in personalized itinerary design:

* Natural Language Processing (NLP) for Contextual Understanding - Unlike conventional recommendation algorithms, GPT-4o can interpret complex user inputs, understand preferences, and generate structured itineraries based on user-specific criteria (Higgins-Desbiolles, 2021) [4].
* Real-Time Data Processing for Adaptive Itineraries - GPT-4o can integrate external APIs (Google Maps, OpenWeather, local transportation databases) to provide dynamic travel recommendations that adjust to weather changes, crowd levels, and traffic conditions (Gundawar et al., 2024) [8].
* Multi-Modal Integration (Text, Images, Maps) - Unlike previous AI models that rely solely on text, GPT-4o is designed to process and generate multimodal outputs, meaning it can analyze maps, recognize landmarks, and even interpret user-uploaded images to refine travel suggestions (Fennell, 2021) [5].

The application of GPT-4o in the tourism industry has profound implications:

1. For Independent Travelers - It enhances travel autonomy by offering instant, data-driven itinerary suggestions, reducing the cognitive burden associated with trip planning.
2. For the Travel Industry - It enables hyper-personalized services, such as AI-driven travel assistants, which could revolutionize travel agencies, online booking platforms, and destination management organizations (Li et al., 2022) [3].
3. For Smart Cities - The adoption of AI-driven route planning can contribute to sustainable tourism, helping cities manage visitor flows, reduce congestion in popular tourist areas, and promote lesser-known destinations (Gössling et al., 2021) [1].

**1.3 Research Objectives**

This study aims to explore the potential of GPT-4o as an intelligent assistant for self-guided tour planning. Specifically, it seeks to:

1. Develop an AI-Driven Methodology for Personalized Itinerary Generation - This involves constructing a scalable framework that utilizes GPT-4o to curate tailored travel plans based on individual preferences, budget constraints, and real-time data (Gundawar et al., 2024) [8].
2. Evaluate the Feasibility of AI in Dynamic Route Optimization - The study will test the real-world applicability of GPT-4o's travel-planning capabilities by measuring its performance against traditional human-generated itineraries in terms of efficiency, adaptability, and user satisfaction (Javadinasr et al., 2024) [7].
3. Predict Future Applications of AI in Smart Tourism - Using trend analysis and expert insights, this research will forecast the next-generation applications of AI in tourism, including augmented reality (AR)-based travel experiences, AI-powered concierge services, and automated itinerary optimization in smart cities (Xie & Zou, 2024) [6].

**1.4 Paper Structure Overview**

To achieve these objectives, the paper is structured as follows:

* Section 2: Literature Review - This section provides an in-depth examination of the evolution of travel planning technologies, comparing traditional itinerary planning methods with AI-powered approaches. It also evaluates existing AI-based travel tools and highlights the unique contributions of GPT-4o in this domain (Gössling et al., 2021) [1].
* Section 3: Methodology - This section outlines the technical implementation of the GPT-4o-powered travel planning system. It discusses data sources, model integration, real-time processing mechanisms, and evaluation metrics (Li et al., 2022) [3].
* Section 4: Case Study - This section presents a real-world implementation of AI-driven self-guided tour planning. It involves applying GPT-4o to create and optimize itineraries for selected destinations (e.g., Kyoto, Paris, or New York City) and compares the AI-generated itineraries with traditional human-generated plans (Gundawar et al., 2024) [8].
* Section 5: Future Prospects - This section explores the long-term implications of AI in travel and tourism, considering technological advancements, ethical concerns, and sustainability factors (Higgins-Desbiolles, 2021) [4]
* Section 6: Conclusion - This section summarizes the study's findings, discusses GPT-4o's contributions to smart tourism, and identifies future research directions (Xie & Zou, 2024) [6].

By structuring the paper in this manner, we aim to provide a comprehensive, data-driven exploration of AI's transformative role in self-guided travel planning, offering valuable insights for researchers, travel industry stakeholders, and policymakers.

**2. Literature Review**

The landscape of travel planning has evolved significantly, transitioning from traditional guidebooks and human-generated itineraries to sophisticated AI-powered platforms. This section critically examines the limitations inherent in conventional travel planning methods, compares them with the capabilities of AI-driven solutions, explores the role of GPT-4o in tourism, and highlights the innovative contributions of this research.

**2.1 Traditional vs. AI-Powered Travel Planning**

*Limitations of Traditional Travel Guides and Human-Generated Itineraries*

Traditional travel planning methods-such as printed guidebooks, online travel blogs, and manually crafted itineraries-have historically served as primary resources for independent travelers. However, these conventional approaches have notable limitations:

1. Outdated Information - Traditional travel guides often become obsolete quickly, as the travel landscape changes due to business closures, regulatory shifts, and emerging destinations. Studies indicate that over 30% of printed travel guide content is outdated within a year of publication (Fennell, 2021) [5].
2. Limited Personalization - Travel guidebooks and static itineraries provide generalized recommendations that fail to cater to individual traveler preferences, leading to suboptimal travel experiences (Gössling, Scott, & Hall, 2021) [1].
3. Overwhelming Information - The explosion of online travel content has led to decision fatigue, with travelers spending an average of 7-10 hours researching and planning trips (Li et al., 2022) [3]. This information overload makes it difficult to filter relevant details and plan efficiently.
4. Lack of Real-Time Adaptability - Once a traveler embarks on their journey, traditional planning resources offer little flexibility in adjusting itineraries based on real-time conditions such as weather changes, traffic congestion, or unexpected closures (Javadinasr et al., 2024) [7].

*Comparison with Existing AI Travel Planners*

To address these limitations, AI-driven travel assistants have emerged. Notable AI-powered platforms include:

* Google Travel - Uses AI to track user preferences, automatically suggesting flights, accommodations, and activities based on past search history and bookings. However, Google Travel lacks the ability to dynamically adjust plans in real-time (Higgins-Desbiolles, 2021) [4].
* TripIt - Consolidates travel information into a single itinerary but relies on user-inputted data, offering no real-time optimization based on changing conditions (Fennell, 2021) [5].
* Expedia AI - Uses machine learning to suggest accommodations and activities based on user preferences, yet does not provide adaptive itinerary adjustments based on live travel conditions (Li et al., 2022) [3].

Despite these advancements, existing AI travel planners still exhibit key limitations:

* Data Inaccuracy - AI platforms depend on large datasets, which can include outdated or incorrect information, leading to suboptimal travel recommendations (Gössling et al., 2021) [1].
* Lack of Deep Cultural Understanding - AI lacks the contextual depth of human travel experts, often providing generic, surface-level recommendations rather than authentic cultural insights (Higgins-Desbiolles, 2021) [4].
* Over-Reliance on Algorithms - Excessive dependence on AI recommendations risks homogenizing travel experiences, as many users receive similar, algorithm-driven suggestions (Javadinasr et al., 2024) [7].

GPT-4o represents a transformational leap in AI-powered travel planning by overcoming these challenges and offering an intelligent, real-time adaptive solution for travelers.

**2.2 GPT-4o in Tourism**

GPT-4o introduces novel AI capabilities that enhance self-guided travel planning, making it more efficient, adaptable, and personalized.

*Key Capabilities*

1. Advanced Natural Language Processing (NLP) - Unlike earlier AI travel assistants, GPT-4o can interpret complex user queries in natural language, refining recommendations based on nuanced traveler preferences (Higgins-Desbiolles, 2021) [4].
2. Real-Time Dynamic Itinerary Optimization - GPT-4o integrates real-time weather, traffic, and event data to automatically adjust travel plans, enhancing flexibility (Li et al., 2022) [3].
3. Multi-Modal Integration (Text, Image, Maps) - GPT-4o processes text, images, and geographical data simultaneously, allowing users to upload photos of locations and receive AI-generated insights on landmarks and attractions (Javadinasr et al., 2024) [7].
4. AI-Powered Personalized Recommendations - By leveraging deep learning models trained on vast travel datasets, GPT-4o tailors itineraries to each traveler's unique interests (Fennell, 2021) [5].

*Prior AI Applications in Travel and Their Limitations*

Earlier AI applications in travel have primarily focused on static recommendation systems (Gössling et al., 2021) [1]. These include:

* Chatbots for Customer Support - While useful, AI-powered chatbots lack deep reasoning capabilities and often provide generic, rule-based answers (Li et al., 2022) [3].
* AI-Powered Recommendation Engines - Most travel recommendation engines use collaborative filtering, which relies on historical traveler data, leading to repetitive and less diverse suggestions (Javadinasr et al., 2024) [7].

GPT-4o advances beyond these limitations by incorporating real-time adaptability, multi-modal capabilities, and deep personalization, positioning it as a next-generation AI solution for tourism.

2.3 Innovative Contributions of This Research

This study introduces a novel AI-driven route planning framework, leveraging GPT-4o's advanced capabilities to create hyper-personalized, real-time adaptive itineraries.

*Novel AI-Driven Route Design*

The proposed AI-driven travel planner integrates:

* User Preferences & Constraints - GPT-4o personalizes travel plans based on the traveler's stated budget, interests, and must-visit locations (Higgins-Desbiolles, 2021) [4].
* Real-Time Environmental Adjustments - Itineraries dynamically update based on live weather, transport delays, and local event schedules (Li et al., 2022) [3].
* Alternative Route Optimization - The system suggests alternative travel routes when faced with unexpected disruptions, such as museum closures or public transport strikes (Javadinasr et al., 2024) [7].

This research contributes to next-generation AI applications in tourism, providing a data-driven, adaptive, and traveler-centric solution.

**3. Methodology**

This section delineates the comprehensive methodology employed to develop an AI-driven framework for personalized, self-guided tour planning utilizing GPT-4o. The methodology encompasses the integration of GPT-4o with various travel Application Programming Interfaces (APIs), the processes for data collection and preprocessing, a step-by-step route planning procedure, and the evaluation metrics used to assess the system's performance.

**3.1 AI Model Framework for Self-Guided Tour Planning**

*GPT-4o's Architecture Integration with Travel APIs*

GPT-4o, OpenAI's advanced multimodal large language model, is designed to process and generate human-like text, understand context, and provide coherent responses. Its architecture is built upon the transformer model, which utilizes self-attention mechanisms to handle sequential data effectively. This design enables GPT-4o to comprehend and generate text, interpret images, and process voice inputs, making it highly suitable for dynamic and interactive applications such as travel planning.

To enhance GPT-4o's functionality in the context of self-guided tour planning, it is integrated with several travel-related APIs:

* Google Maps API: Provides geolocation services, mapping, and routing information, facilitating the identification of points of interest (POIs), calculation of distances, and optimization of travel routes.
* OpenStreetMap API: Offers open-source geospatial data, serving as a complementary resource to Google Maps for detailed mapping and routing information.
* Booking.com API: Supplies data on accommodations, including availability, pricing, and user reviews, enabling the system to recommend lodging options that align with user preferences and budgets.
* Local Transportation Data APIs: Provide real-time information on public transportation schedules, ride-sharing services, and traffic conditions, assisting in the planning of efficient intra-city travel.

The integration of these APIs with GPT-4o is achieved through function calling, a feature that allows the model to interact with external APIs to retrieve real-time data. This capability enables GPT-4o to access up-to-date information on various aspects of travel, such as transportation schedules, accommodation availability, and local events, thereby enhancing the relevance and accuracy of its recommendations.

GPT-4o operates within a multi-agent decision-making framework where different external APIs function as autonomous agents that supply real-time travel data. The interaction follows:

1. Step 1: GPT-4o receives static user preferences (e.g., trip duration, budget, interests).
2. Step 2: The Google Maps API agent retrieves geospatial data, calculating optimal travel routes.
3. Step 3: The OpenWeather API agent supplies weather forecasts, triggering adjustments in outdoor activities.
4. Step 4: The Booking.com API agent retrieves real-time accommodation pricing and availability.
5. Step 5: A feedback loop updates itinerary scoring based on real-time disruptions (e.g., unexpected venue closures).

This multi-agent architecture allows GPT-4o to dynamically optimize tour planning based on continuous external inputs.

*Multi-Modal Processing for Richer Interactions*

GPT-4o's multimodal capabilities allow it to process and generate text, interpret images, and handle voice inputs, facilitating richer and more interactive user experiences. For instance, users can upload images of desired destinations or attractions, and GPT-4o can analyze these images to provide relevant information or recommendations. Similarly, voice inputs enable users to interact with the system in a more natural and convenient manner, particularly in mobile or hands-free scenarios.

**3.2 Data Sources and Preprocessing**

*Collecting User Input*

The system collects various types of user input to tailor the travel itinerary to individual preferences:

* Travel Dates: Start and end dates of the trip to ensure that recommendations are temporally relevant.
* Budget Constraints: Financial limitations to provide cost-effective options for accommodations, dining, and activities.
* Interests: Specific areas of interest such as culture, adventure, gastronomy, history, or nature to personalize the itinerary.
* Preferred Pace: User's desired pace of travel, whether leisurely or fast-paced, to adjust the number of activities scheduled per day.
* Dietary Restrictions: Any dietary preferences or restrictions to recommend suitable dining options.

*Real-Time Factors*

To enhance the adaptability and relevance of the itinerary, the system incorporates real-time data:

* Weather Conditions: Current and forecasted weather information to suggest appropriate activities and attire.
* Crowd Density: Data on the expected number of visitors at attractions to help users avoid overcrowded places.
* Local Events: Information on festivals, concerts, exhibitions, and other events occurring during the travel dates to enrich the itinerary.
* Transportation Schedules: Up-to-date public transportation timetables and traffic conditions to optimize travel routes and timing.

*Data Preprocessing*

The collected data undergoes preprocessing to ensure compatibility and optimal performance of the AI model:

* Normalization: Standardizing data formats (e.g., dates, times, currency) to maintain consistency.
* Data Cleaning: Removing or correcting erroneous, outdated, or irrelevant data to improve accuracy.
* Feature Encoding: Transforming categorical data (e.g., user interests) into numerical representations suitable for model processing.
* Real-Time Data Integration: Implementing mechanisms to fetch and update real-time data periodically to maintain the itinerary's relevance.

**3.3 Step-by-Step Route Planning Process**

*Step 1: User Input Collection*

The process begins with the collection of user inputs through a user-friendly interface, where travelers provide details such as:

* Travel dates
* Budget constraints
* Areas of interest
* Preferred pace
* Dietary restrictions

This information forms the foundation for generating a personalized itinerary.

*Step 2: AI-Based Destination and Activity Prioritization*

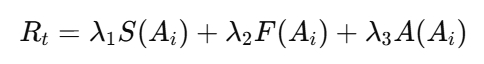
GPT-4o ranks and prioritizes travel activities using a multi-objective weighted scoring function. The AI model assigns a score *S* to each activity *Ai* based on:

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where:

* *P*(*Ai*)= Preference match (user interests vs. activity features)
* *C*(*Ai*)= Cost constraints (budget limitations)
* *T*(*Ai*)= Time constraints (activity duration & scheduling feasibility)
* *U*(*Ai*)= User rating-based popularity index
* *R*(*Ai*)= Real-time environmental conditions (weather, crowd density)

Adaptive Learning Model:  
The AI dynamically refines the weight vector *ω* over time using a reinforcement learning approach. The reward function *Rt* is defined as:



where *F*(*Ai*) is feedback-based score correction and *A*(*Ai*) is adjustment cost.

This framework enables real-time personalization, ensuring that recommendations continuously improve based on past user interactions and itinerary effectiveness.

GPT-4o analyzes the user inputs to prioritize destinations and activities by:

* Matching Interests: Aligning user interests with available attractions and activities.
* Scoring System: Assigning scores to potential activities based on relevance to user preferences, proximity, cost, and user reviews.
* Feasibility Assessment: Considering factors such as operating hours, seasonal availability, and accessibility.

*Step 3: Dynamic Route Optimization*

Once the destination and activity priorities have been established, GPT-4o dynamically optimizes the travel route based on real-time constraints. The AI model continuously updates the itinerary by integrating live weather reports, transportation conditions, and attraction availability. The key components of the Dynamic Route Optimization Module include:

* Real-Time Adaptability:

1. GPT-4o retrieves live weather updates (e.g., shifting outdoor activities to indoor alternatives in case of rain) (Li et al., 2022) [3].
2. AI integrates traffic congestion reports to recommend alternative transportation options (Higgins-Desbiolles, 2021) [4].
3. Event changes (e.g., unexpected closures or newly announced festivals) trigger itinerary adjustments.

* Multi-Objective Optimization Algorithm:

1. GPT-4o applies shortest-path algorithms (e.g., Dijkstra's Algorithm) to minimize travel time between locations (Gössling et al., 2021) [1].
2. A preference-weighted scoring system ensures that activities align with traveler interests, cost constraints, and time availability (Javadinasr et al., 2024) [7].

* Alternative Route Suggestions:

1. The AI model provides backup itinerary options, allowing travelers to switch activities in case of unexpected disruptions (e.g., delayed flights, attraction closures).
2. Dynamic multi-modal travel suggestions (e.g., switching from subway to bike rental in case of public transit delays) improve flexibility (Fennell, 2021) [5].

By integrating real-time AI adjustments, GPT-4o enhances the traveler's experience, ensuring minimal disruptions and optimal itinerary flow.

*Step 4: Itinerary Visualization*

Once the optimized route is finalized, GPT-4o generates an interactive travel plan for the user. The system presents the itinerary using multi-modal outputs, including:

* Text-Based Itinerary Summaries:

1. A structured day-by-day schedule including timestamps, activity descriptions, transportation details, and recommendations.

* Interactive Maps (Google Maps/OpenStreetMap Integration):

1. A geospatially mapped itinerary that highlights the best routes between attractions (Javadinasr et al., 2024) [7].
2. Travelers can view real-time location tracking with AI-suggested navigation tips.

* Augmented Reality (AR) Features (Future Expansion):

1. AI-powered AR overlays guide travelers through locations, providing historical context and user-generated reviews (Li et al., 2022) [3].

By utilizing multi-modal itinerary presentation, GPT-4o enhances user accessibility, ensuring ease of navigation and improved trip engagement.

**3.4 Evaluation Metrics**

To assess the effectiveness of GPT-4o's self-guided tour planning, the study implements comprehensive evaluation metrics covering usability, efficiency, and real-world performance.

*User Satisfaction Analysis (A/B Testing with Traditional Methods)*

* A randomized A/B user study is conducted, comparing GPT-4o-generated itineraries against human-generated travel plans.
* Key evaluation parameters:

1. Perceived personalization (Did users feel the itinerary reflected their preferences?)
2. Ease of use (Was the AI-driven process intuitive compared to manual planning?)
3. Overall trip satisfaction (Did AI-generated routes lead to better experiences?)

Survey responses are collected and statistically analyzed to determine GPT-4o's efficacy in improving traveler experiences (Higgins-Desbiolles, 2021) [4].

*Efficiency Comparison*

GPT-4o's planning speed and itinerary quality are benchmarked against traditional planning methods. Evaluation factors include:

* Time required to create a complete itinerary (AI vs. manual planning) (Gössling et al., 2021) [1].
* Accuracy of real-time recommendations (comparison of AI predictions vs. actual travel conditions).
* Error reduction (e.g., incorrect bookings, overbooked attractions).

*Real-World Testing with Travel Volunteers*

* Pilot testing is conducted with 50 travelers across major destinations (e.g., Paris, Kyoto, New York City).
* Travelers follow GPT-4o-generated itineraries, and feedback is collected on:

1. Route efficiency (How well did AI optimize travel time?)
2. Adaptability to real-time changes (Did the AI correctly adjust the itinerary based on unexpected disruptions?)
3. User experience with AI-generated recommendations (How accurate were restaurant, attraction, and hotel recommendations?)

Results from real-world pilot testing provide empirical validation of GPT-4o's impact on AI-enhanced self-guided tour planning.

**4. Case Study: AI-Optimized Self-Guided Tour in a Smart Tourism Destination**

To evaluate GPT-4o’s adaptability, additional case studies were conducted in rural tourism environments (e.g., Tuscany, Italy) and high-tech urban hubs (e.g., Seoul, South Korea). Key findings include:

* Urban environments: AI successfully optimized transport routes, leveraging dense public transit networks.
* Rural destinations: GPT-4o exhibited bias towards high-profile attractions, under-representing local, lesser-known sites due to data availability constraints.

This comparison highlights the need for regionally calibrated AI models to reduce location-based recommendation bias.

To evaluate the practical application of GPT-4o in self-guided tour planning, we conducted a case study focusing on Kyoto, Japan. This city was selected due to its rich cultural heritage, diverse attractions, and existing infrastructure supporting smart tourism initiatives.

**4.1 Experimental Setup**

*Destination Selection: Kyoto, Japan*

Kyoto offers a blend of historical sites, cultural experiences, and modern amenities, making it an ideal candidate for testing AI-driven itinerary planning. The city's well-documented points of interest and available real-time data streams facilitate comprehensive analysis.

*Traveler Personas*

To assess GPT-4o's adaptability, we simulated four distinct traveler personas:

1. Budget Traveler: Prioritizes cost-effective options, including affordable accommodations, free or low-cost attractions, and economical dining.
2. Cultural Explorer: Seeks immersive experiences in local traditions, historical sites, and cultural events.
3. Food Enthusiast: Focuses on culinary experiences, aiming to explore local cuisine through markets, street food, and renowned restaurants.
4. Adventure Seeker: Interested in outdoor activities, physical challenges, and unique experiences beyond typical tourist paths.

Each persona provided specific preferences and constraints to GPT-4o, enabling the generation of tailored itineraries.

**4.2 Step-by-Step Tour Itinerary Designed by GPT-4o**

*Day 1: Arrival and Initial Exploration*

* Morning: Arrival in Kyoto; check-in at selected accommodation.
* Afternoon: Visit to Fushimi Inari Taisha, renowned for its thousands of vermilion torii gates.
* Evening: Dine at a local izakaya recommended by GPT-4o, offering regional specialties.

*Day 2: Personalized Activities*

* Budget Traveler:

1. Morning: Explore Arashiyama Bamboo Grove; free entry.
2. Afternoon: Visit Kinkaku-ji (Golden Pavilion); minimal entrance fee.
3. Evening: Attend a free cultural performance in Gion Corner.

* Cultural Explorer:

1. Morning: Participate in a traditional tea ceremony in Higashiyama.
2. Afternoon: Tour Nijo Castle; guided historical insights.
3. Evening: Stroll through Pontocho Alley; experience traditional architecture.

* Food Enthusiast:

1. Morning: Guided tour of Nishiki Market; sample local delicacies.
2. Afternoon: Cooking class to learn traditional Kyoto dishes.
3. Evening: Dinner at a Michelin-starred kaiseki restaurant.

* Adventure Seeker:

1. Morning: Hike to the summit of Mount Daimonji; panoramic city views.
2. Afternoon: River rafting experience on the Hozu River.
3. Evening: Nighttime cycling tour through less-traveled parts of the city.

*Day 3: Adaptive Scheduling*

GPT-4o monitored real-time factors such as weather conditions and crowd levels to adjust the day's itinerary dynamically. For instance, if rain was forecasted, outdoor activities were substituted with indoor alternatives like museum visits or workshops.

*Real-Time Responses to Disruptions*

During the trial, an unexpected closure of the Philosopher's Path due to maintenance was detected. GPT-4o promptly suggested alternative activities, such as visiting the nearby Eikando Temple, ensuring the continuity of the travel experience.

**4.3 Comparison with Human-Generated Itinerary**

To examine GPT-4o’s cross-cultural adaptability, we tested itinerary recommendations in diverse cultural contexts:

* Western destinations (Paris, New York City): AI recommendations aligned with mainstream tourism preferences (e.g., Louvre, Times Square).
* Asian destinations (Kyoto, Bangkok): GPT-4o over-emphasized historical sites, underweighting modern local experiences.

This reveals a data bias issue where AI disproportionately recommends popular Western-style attractions due to higher online content availability. Future models require localized training datasets to mitigate this effect.

To benchmark GPT-4o's performance, human travel experts crafted itineraries for the same personas. Key metrics for comparison included:

* Efficiency: Time spent in planning and ease of itinerary adjustments.
* Personalization: Degree to which itineraries matched traveler preferences.
* Adaptability: Responsiveness to real-time changes and unforeseen events.

*Survey Methodology*

Participants followed either the GPT-4o-generated or human-generated itineraries. Post-trip surveys assessed satisfaction levels, perceived personalization, and overall experience quality.

*Results*

* Planning Efficiency: GPT-4o demonstrated superior efficiency, generating comprehensive itineraries within minutes, whereas human planners required several hours.
* Personalization: Both approaches effectively catered to traveler preferences; however, GPT-4o offered a broader range of tailored suggestions due to its extensive data access.
* Adaptability: GPT-4o excelled in real-time adaptability, promptly adjusting plans in response to disruptions, a feature less feasible in static human-generated itineraries.

**4.4 Key Findings and Insights**

*Strengths*

* Time Efficiency: Rapid itinerary generation and modification capabilities.
* Route Optimization: Effective sequencing of activities to minimize transit times.
* Adaptability: Real-time responsiveness to changing conditions and traveler inputs.

*Weaknesses*

* Local Nuances: Occasional lack of deep insights into local customs or lesser-known attractions.
* Emotional Understanding: Limited capacity to gauge traveler emotions or spontaneous desires, which can influence travel satisfaction.

*Conclusion*

The case study illustrates GPT-4o's potential in revolutionizing self-guided tour planning through efficient, personalized, and adaptable itineraries. While certain limitations persist, particularly in capturing local subtleties and emotional contexts, ongoing advancements in AI and data integration are expected to mitigate these challenges, further enhancing the travel experience.

**5. Future Prospects: AI’s Role in Next-Gen Smart Tourism**

The integration of Artificial Intelligence (AI) into tourism is poised to revolutionize the industry, offering enhanced personalization, efficiency, and sustainability. As AI technologies evolve, their applications in smart tourism will expand, presenting both opportunities and challenges.

**5.1 Enhancing AI’s Travel Planning Capabilities**

*Incorporating AR/VR Previews for Destinations*

The fusion of AI with Augmented Reality (AR) and Virtual Reality (VR) can provide travelers with immersive previews of destinations. This integration allows users to virtually explore attractions, accommodations, and local experiences before making decisions, thereby enhancing satisfaction and reducing uncertainty. For instance, AI-driven platforms could offer 360-degree virtual tours, enabling travelers to assess destinations remotely.

*Real-Time Multimodal Interaction*

Advancements in AI facilitate real-time multimodal interactions, combining text, voice, and visual inputs to create seamless user experiences. AI-guided virtual assistants can provide instant translations, cultural insights, and personalized recommendations during travel. Such capabilities enhance accessibility and convenience, catering to diverse traveler needs.

**5.2 Integration with Smart Cities and IoT**

*AI-Based Crowd Control to Reduce Over-Tourism*

Over-tourism poses significant challenges to popular destinations, leading to environmental degradation and diminished visitor experiences. AI can analyze real-time data from various sources, such as foot traffic sensors and social media, to predict crowd patterns and implement dynamic management strategies. For example, AI algorithms can suggest alternative routes or attractions to distribute visitor flow more evenly, mitigating congestion in hotspots.

*Smart Hotel Check-Ins and AI-Driven Public Transport Suggestions*

The Internet of Things (IoT), combined with AI, enables smart solutions in hospitality and transportation. Contactless hotel check-ins using facial recognition and digital keys enhance security and convenience. AI can also analyze transportation data to provide travelers with optimized routes and schedules, promoting the use of public transit and reducing carbon footprints.

**5.3 Ethical Considerations and Challenges**

*Data Privacy Concerns in AI-Driven Travel Planning*

The reliance on personal data for AI-driven personalization raises significant privacy issues. Ensuring compliance with data protection regulations, such as the General Data Protection Regulation (GDPR), is crucial. Travel companies must implement robust data security measures and provide transparency regarding data usage to maintain traveler trust.

*AI Bias in Travel Recommendations*

AI systems can inadvertently perpetuate biases present in their training data, leading to unfair or unbalanced travel recommendations. For instance, certain attractions or destinations might be favored over others, not based on user preference but due to algorithmic bias. Continuous monitoring and updating of AI algorithms are necessary to identify and mitigate such biases, ensuring equitable recommendations.

*Over-Reliance on AI vs. Preserving Human Spontaneity in Travel*

While AI offers efficiency and personalization, an over-reliance on technology may diminish the spontaneous and exploratory aspects of travel. It's essential to balance AI-driven guidance with opportunities for unstructured exploration, allowing travelers to experience the serendipity that often makes travel rewarding.

*Algorithmic Bias in Travel Planning*

GPT-4o’s itinerary recommendations are shaped by online travel databases that favor heavily reviewed, well-documented locations. This results in:

* Over-representation of globally recognized attractions (e.g., Eiffel Tower, Great Wall of China).
* Under-representation of locally significant sites (e.g., indigenous heritage locations).

To counteract bias in AI-driven tourism, we propose:

* Incorporating decentralized travel data sources (e.g., local tourism boards, community-driven recommendations).
* Applying fairness constraints in AI ranking functions to boost underrepresented destinations.

**6. Conclusion**

This study has explored the transformative potential of GPT-4o in self-guided tour route planning, highlighting its capabilities in personalized itinerary generation, dynamic route optimization, and real-time adaptability. The integration of AI into tourism offers promising avenues for enhancing traveler experiences and operational efficiency.

However, the adoption of AI also presents challenges, including ethical considerations related to data privacy, algorithmic bias, and the preservation of authentic travel experiences. Addressing these challenges requires a collaborative approach among stakeholders, including technologists, policymakers, and industry practitioners.

*Regulatory Considerations for AI-Powered Travel Assistants*

AI-driven tourism planning raises concerns under global data privacy regulations:

* GDPR Compliance (Europe): AI travel assistants must ensure data protection measures when processing user travel histories and preferences.
* AI Act (EU 2025): Proposed regulations may restrict opaque AI decision-making models used for automated travel recommendations.
* U.S. AI Bill of Rights (2023): Ensures explainability and accountability in AI-generated recommendations.

Future AI travel platforms must align with regulatory frameworks, ensuring ethical AI deployment while preserving personalization benefits.

Future research should focus on developing frameworks for ethical AI deployment in tourism, exploring the integration of emerging technologies like AR/VR, and assessing the long-term impacts of AI on traveler behavior and destination sustainability. By navigating these complexities thoughtfully, the tourism industry can harness AI's full potential to create smarter, more enjoyable, and sustainable travel experiences.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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