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Development of an AI-Based Marine Tourism Chatbot with Multilingual Voicebot

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Abstract

The rapid growth of coastal tourism in Banten Province has intensified the demand for innovative digital solutions capable of improving information accessibility, service efficiency, and visitor experience. However, existing tourism information systems in regional coastal areas often remain fragmented, language-limited, and lacking real-time interactive capabilities. This study presents the development and evaluation of an artificial intelligence–based interactive chatbot integrated with multilingual voicebot capabilities to support smart tourism services at major coastal destinations in Banten, Indonesia. The system combines natural language processing (NLP), automatic speech recognition (ASR), text-to-speech synthesis (TTS), and geospatial information services within a unified mobile-based architecture to enable interactive and context-aware tourism information delivery. A multilingual tourism dataset consisting of 720 validated question–answer pairs across seven languages was constructed and utilized to fine-tune a transformer-based language model. The system architecture was designed to support real-time interaction through an asynchronous backend and optimized processing pipeline. System performance was evaluated using quantitative metrics, including BLEU score for conversational accuracy, word error rate for speech recognition, mean opinion score for speech synthesis quality, and response latency analysis. In addition, field testing was conducted with 50 users at several coastal tourism sites to assess usability and user satisfaction. This evaluation approach allows both technical performance and user experience aspects to be assessed in real-world tourism scenarios. The evaluation results demonstrate strong system performance, achieving an average BLEU score of 82%, a word error rate of 12%, a mean opinion score of 4.2, and an average response time of 0.7 seconds. User evaluation further indicates a high level of usability and overall satisfaction. These findings confirm that the proposed chatbot system effectively enhances tourism information services in coastal destinations and provides a scalable technological foundation for sustainable smart tourism development in regional tourism contexts. The proposed approach also provides a practical framework for integrating AI-driven conversational systems into regional smart tourism ecosystems.

Keywords: Smart tourism; artificial intelligence; chatbot; voicebot; coastal tourism; multilingual system

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1. Introduction

Smart tourism has emerged as a strategic paradigm that leverages digital technologies to improve tourism services, enhance visitor experiences, and support sustainable destination management. The integration of information and communication technologies enables tourism stakeholders to deliver personalized, context-aware, and data-driven services to tourists before, during, and after their visits (Buhalis & Amaranggana, 2015). Through smart tourism initiatives, destinations can optimize resource utilization, improve service quality, and strengthen competitiveness in an increasingly digital tourism ecosystem

In recent years, artificial intelligence (AI) has played a central role in this transformation by enabling intelligent interaction between users and digital tourism platforms. These capabilities enable tourism systems to provide adaptive, real-time, and personalized services that align with the dynamic needs of modern travelers. AI technologies facilitate automated information delivery, adaptive personalization, and predictive analytics, allowing tourism systems to respond

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dynamically to user needs and contextual changes (García-Madurga et al., 2023; López-Naranjo et al., 2025). As a result, AI-driven solutions are increasingly recognized as key enablers of smart and sustainable tourism development.

Among AI-based technologies, chatbots have gained significant attention due to their ability to provide real-time information, automate customer service, and enhance user engagement. Chatbots serve as virtual assistants capable of handling repetitive inquiries, offering travel recommendations, and supporting tourists throughout their travel journey. Previous studies have demonstrated that AI-powered chatbots positively influence tourist satisfaction, destination decision-making, and service efficiency by reducing information search costs and improving service responsiveness (Benaddi et al., 2024; Orden-Mejía et al., 2025). These benefits are particularly relevant in tourism contexts where timely and accurate information is critical. In addition, chatbot systems reduce operational costs and enable continuous service availability, which is particularly important in tourism environments with fluctuating visitor demand.

Furthermore, voice-based interaction has become increasingly relevant in tourism services. Voice assistants enable hands-free access to information, which is especially useful for tourists who are navigating unfamiliar environments or engaging in outdoor activities. Voice-based systems also support inclusive tourism by accommodating users with visual impairments or limited digital literacy and by reducing language barriers for international visitors (Buhalis et al., 2022; Magano & Buhalis, 2025). The growing adoption of smart speakers and mobile voice assistants further underscores the importance of integrating voicebot features into tourism information systems. This is particularly beneficial in outdoor tourism contexts, where hands-free interaction and quick access to information significantly enhance user convenience.

Despite these advances, many existing tourism chatbot implementations still exhibit critical limitations. Most systems rely primarily on text-based interaction and offer limited multilingual support, often focusing only on widely spoken languages such as English. This limitation restricts accessibility for tourists from diverse linguistic backgrounds and reduces the inclusivity of digital tourism services. In addition, many chatbot solutions are developed for large metropolitan destinations or global tourism platforms, leaving regional and peripheral destinations underrepresented in empirical research and technological innovation (Ilieva & Petrova, 2024; Sousa et al., 2024).

Another significant limitation concerns the integration of spatial information. Tourism is inherently location-based, and access to maps, routes, and nearby attractions is essential for effective destination exploration. However, the incorporation of geographic information systems (GIS) and location-based services into conversational tourism systems remains relatively limited. Existing studies indicate that spatial data analysis and GIS integration can enhance destination planning and tourist mobility, yet these capabilities are rarely embedded within chatbot-based interfaces, particularly in coastal and regional tourism contexts (Xu et al., 2022; Zhang et al., 2023).

Coastal tourism destinations present unique challenges and opportunities for smart tourism development. These destinations often cover wide geographic areas, involve outdoor activities, and experience fluctuating visitor flows influenced by weather and seasonal factors. Consequently, tourists require timely, accurate, and location-specific information related to attractions, facilities, safety, and transportation. AI-based conversational systems integrated with spatial information have the potential to address these needs by providing interactive, real-time guidance tailored to users' locations and preferences. Furthermore, the lack of integration between conversational AI and spatial information systems limits the ability of existing solutions to provide context-aware tourism guidance.

Banten Province is a coastal tourism region in Indonesia with diverse and well-known destinations, including Anyer, Carita, Tanjung Lesung, Pulau Merak Kecil, Sawarna, and Bagedur beaches. These destinations attract both domestic and international tourists due to their natural landscapes and proximity to major urban centers. However, tourism information services in Banten Province remain fragmented and largely manual, relying on physical information boards, local guides, and non-integrated online sources. This situation creates information gaps, particularly for foreign tourists who face language barriers and limited access to reliable digital guidance. In this context, digital transformation is not only a technological shift but also a strategic necessity to ensure competitiveness and sustainability in the tourism sector. These conditions also highlight the need for an integrated digital solution capable of providing multilingual, real-time, and location-based tourism information services.

Addressing linguistic diversity and real-time information needs is therefore essential to support sustainable smart tourism development in Banten Province. Multilingual digital services can improve accessibility, enhance visitor satisfaction, and promote longer stays and repeat visits. Moreover, AI-based systems can support destination management organizations by providing insights into tourist behavior, frequently requested information, and service demand patterns, thereby contributing to data-driven tourism governance.

From a theoretical perspective, user acceptance plays a critical role in the success of AI-based tourism systems. Prior studies indicate that perceived usefulness, ease of use, trust, and system reliability significantly influence user adoption,

particularly in emerging and developing regions. In addition, technological readiness and user familiarity with digital services may affect interaction patterns with conversational AI. Therefore, incorporating user-centered design principles is essential to ensure the effectiveness and sustainability of AI-driven tourism applications.

In response to these challenges, this study aims to develop and validate an AI-based interactive chatbot integrated with multilingual voicebot features and GIS support for coastal tourism promotion in Banten Province. The proposed system is designed to deliver text- and voice-based interactions in multiple languages, provide spatially contextualized tourism information, and operate efficiently within a mobile application environment suitable for real-world deployment.

The main contributions of this research are threefold. First, this study constructs a multilingual tourism dataset specifically tailored to coastal destinations, addressing the lack of localized and language-diverse training data in existing tourism chatbot research. Second, it integrates natural language processing (NLP), automatic speech recognition (ASR), text-to-speech synthesis (TTS), and GIS within a unified mobile platform, offering a comprehensive conversational tourism solution. Third, the study provides an empirical evaluation of system performance and user acceptance through field testing in real tourism settings, contributing practical evidence to the growing body of smart tourism literature.

By focusing on a regional coastal tourism context and emphasizing multilingual voice interaction and spatial integration, this research extends current smart tourism studies and demonstrates the potential of AI-driven conversational systems to support sustainable tourism development beyond metropolitan destinations.

This study distinguishes itself from previous works by integrating multilingual NLP, voice-based interaction, and GIS-based information delivery within a single mobile platform tailored specifically for coastal tourism environments.

2. Methods

This study employed a research and development approach focusing on the design, implementation, and evaluation of an AI-based interactive chatbot system for coastal tourism. The methodological framework consisted of four main stages: dataset development, system architecture design, model implementation, and system evaluation.

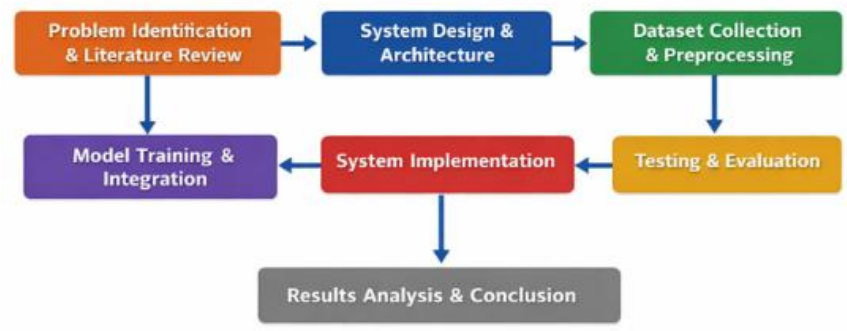

Figure 1. Research Workflow

The first stage involved the construction of a multilingual tourism dataset. Data were collected from official tourism websites, regional tourism documents, and manually curated content relevant to coastal tourism in Banten Province. The dataset comprised 720 question–answer pairs in seven languages: Indonesian, English, Japanese, Mandarin, Arabic, French, and German. Linguistic validation, normalization, and transliteration were applied to ensure semantic consistency across languages.

In the second stage, the system architecture was designed using a modular approach. The mobile application was developed using Flutter, while the backend services were implemented using FastAPI to support asynchronous request handling. The chatbot module employed a fine-tuned GPT-2 language model for natural language understanding and response generation. Voice interaction was enabled through the Whisper ASR model for speech-to-text processing and the VITS model for text-to-speech synthesis. Geospatial services were integrated to provide location-based tourism information.

The third stage focused on model training and integration. The language model was fine-tuned using the constructed dataset, while the ASR and TTS components were optimized through additional training and parameter adjustment.

System optimization techniques such as response caching and asynchronous processing were implemented to reduce latency.

The final stage involved system evaluation through quantitative performance metrics and user testing. Chatbot performance was measured using BLEU scores, voice recognition accuracy was evaluated using word error rate (WER), and speech synthesis quality was assessed using mean opinion score (MOS). Field testing was conducted with 50 respondents at selected coastal tourism locations to evaluate usability, responsiveness, and user satisfaction.

2.1. Dataset Development

A multilingual tourism dataset comprising 720 question–answer pairs was constructed in seven languages: Indonesian, English, Japanese, Mandarin, Arabic, French, and German. Data were collected from official tourism websites, regional promotional materials, and field observations at coastal destinations. Linguistic normalization, translation verification, and semantic validation were applied to ensure consistency and relevance across languages (Yadav et al., 2022; Sharma & Gupta, 2024).

To improve dataset transparency, the distribution of question–answer pairs across languages is described as follows: Indonesian (150), English (130), Japanese (110), Mandarin (100), Arabic (80), French (75), and German (75). This distribution reflects both data availability and linguistic diversity considerations, ensuring balanced multilingual representation while maintaining contextual relevance for coastal tourism scenarios.

Table 1. Multilingual Tourism Dataset Construction

Aspect	Description
Data Sources	Official tourism websites, regional tourism offices, field observations
Languages	Indonesian, English, Japanese, Mandarin, Arabic, French, German
Data Type	Question–Answer pairs related to coastal tourism information
Total Entries	720 validated QA pairs
Preprocessing	Text cleaning, normalization, translation, semantic validation
Output	Multilingual tourism knowledge base

2.2. Chatbot and Voicebot Modeling

The chatbot component was developed by fine-tuning a GPT-2-based transformer model, selected for its efficiency and suitability for domain-specific adaptation (Radford et al., 2019; Vaswani et al., 2017; Wolf et al., 2020). For voice interaction, the Whisper model was implemented for automatic speech recognition due to its robustness in multilingual environments (Radford et al., 2022, 2023). Text-to-speech synthesis was handled using the VITS architecture to generate natural-sounding multilingual speech output (Kim et al., 2021; van den Oord et al., 2016).

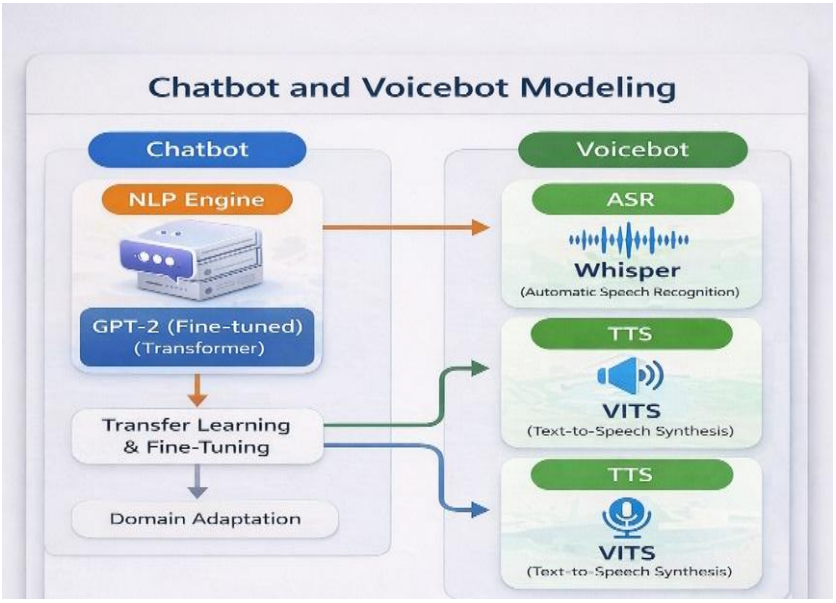

Figure 2. Chatbot and Voice AI Modeling

2.3. Model Fine-Tuning and Optimization

To improve the transparency and reproducibility of the proposed system, the fine-tuning process of the chatbot model is formally described in this section. The chatbot component was developed using a transformer-based autoregressive language model, where the objective is to predict the next token given a sequence of previous tokens.

Given an input sequence $x_1, x_2, \ldots, x_n$, the model estimates the conditional probability:

$$P(x_t|x_1, x_2, \ldots, x_{t-1}) \quad (1)$$

The training objective is to minimize the negative log-likelihood (NLL) loss:

$$\mathcal{L} = -\sum_{t=1}^{n} \log P(x_t|x_{<t}) \quad (2)$$

This formulation allows the model to learn contextual dependencies across multilingual conversational data. The fine-tuning process was conducted using domain-specific tourism data to improve response relevance and contextual accuracy.

Model optimization was conducted using the AdamW optimizer due to its stability and suitability for transformer-based architectures. The model was fine-tuned using the multilingual tourism dataset through iterative training until convergence in validation performance was observed. This approach was selected to balance computational efficiency and domain adaptation quality.

2.4. System Architecture

The system architecture consists of a Flutter-based mobile application, a FastAPI backend server, AI processing modules, Firebase services, and GIS integration. Asynchronous request handling and response caching were employed to reduce latency and improve scalability (Hariri et al., 2023; Chen & Li, 2025).

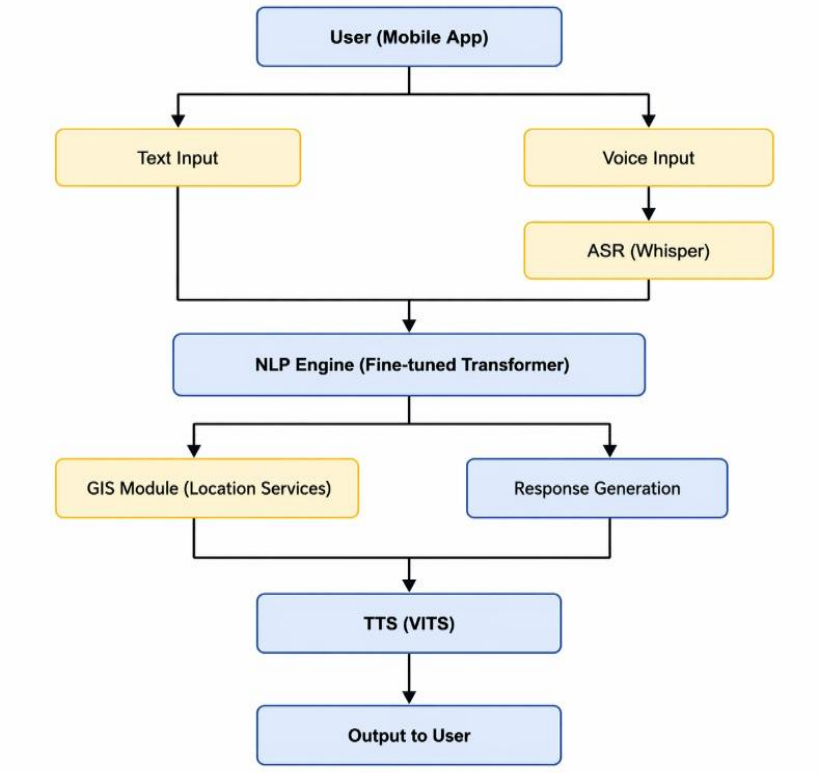

Figure 3. Integrated System Architecture

The proposed system follows a structured processing pipeline that integrates speech recognition, natural language processing, and geospatial data retrieval to generate context-aware responses. This pipeline ensures efficient handling of multilingual inputs and supports both text and voice-based interaction in real-time.

2.5. Evaluation Design

System performance was evaluated using BLEU score to measure conversational relevance, word error rate (WER) for ASR accuracy, mean opinion score (MOS) for TTS quality, and response latency. Usability evaluation involved 50 respondents using a Likert-scale questionnaire, following established evaluation practices in chatbot research (Deng et al., 2023; Potts et al., 2023).

Table 2. Evaluation Metrics and Methods

Aspect Evaluated	Metric	Description
NLP Accuracy	BLEU Score	Text response relevance
ASR Performance	Word Error Rate (WER)	Speech recognition accuracy
TTS Quality	Mean Opinion Score (MOS)	Naturalness of synthesized voice
System Performance	Latency (seconds)	Response time
User Acceptance	Likert Scale Survey	Usability & satisfaction

3. Result and Discussion

The experimental results indicate that the proposed chatbot system achieved robust performance across all evaluated components. The fine-tuned language model produced an average BLEU score of 82%, demonstrating a substantial improvement compared to the baseline model prior to dataset expansion. This result confirms that the multilingual dataset significantly enhanced response relevance and contextual accuracy.

In addition, the integration of multiple AI components within a unified system demonstrates the practical feasibility of deploying real-time conversational tourism assistants in regional contexts. The combination of NLP, ASR, and TTS modules enables seamless interaction, while GIS integration enhances contextual relevance by incorporating spatial information. Compared to conventional tourism information systems, which often rely on static content and limited interaction, the proposed system offers a dynamic and adaptive user experience. This improvement is particularly important in coastal tourism environments where real-time decision-making and accessibility significantly influence user satisfaction. Furthermore, the system architecture demonstrates scalability potential, allowing future integration with additional data sources such as weather, transportation, and event information.

3.1. Results of NLP Performance Evaluation

The multilingual chatbot achieved an average BLEU score of 82.0%, indicating strong semantic relevance and contextual accuracy across languages. Indonesian and English produced the highest scores due to richer training data and linguistic similarity to the base model. Slightly lower scores in Mandarin and Arabic reflect higher linguistic complexity and tokenization challenges, which are consistent with findings in multilingual NLP research. Overall, the results confirm that the fine-tuned model generalizes effectively across diverse languages

Table 3. Multilingual Chatbot Performance (BLEU Score)

Language	BLEU Score (%)
Indonesian	85.1
English	83.4
Japanese	80.6
Mandarin	78.9
Arabic	79.3
French	82.1
German	81.7
Average	**82.0**

Based on Table 3, the chatbot demonstrates consistent performance across multiple languages.

3.2. Voicebot Performance Evaluation

For voice interaction, the ASR module achieved an average word error rate of 12.2 %, with higher accuracy observed in Indonesian and English compared to Mandarin and Arabic. The TTS module obtained an average mean opinion score of 4.2, indicating that synthesized speech was perceived as natural and intelligible by users. These results are comparable to or exceed those reported in previous tourism voice assistant studies (Buhalis et al., 2022; Wang & Huang, 2023).

Table 4. Automatic Speech Recognition Performance (WER)

Language	WER (%) ↓
Indonesian	9.8
English	10.5
Japanese	13.1
Mandarin	14.2
Arabic	15.0
French	11.7
German	10.9
Average	**12.2**

3.1 Text-to-Speech Quality Assessment

The TTS module recorded an average MOS of 4.2, indicating high perceived naturalness and intelligibility of synthesized speech. Respondents rated Indonesian and English voices as most natural, while Arabic received slightly lower scores due to prosodic complexity. Nevertheless, all languages achieved MOS values above 3.8, confirming the suitability of the voicebot for multilingual tourist assistance.

Table 5. Mean Opinion Score (MOS) for TTS Quality

Language	MOS (1–5)
Indonesian	4.4
English	4.3
Japanese	4.1
Mandarin	4.0
Arabic	3.9
French	4.2
German	4.1
Average	**4.2**

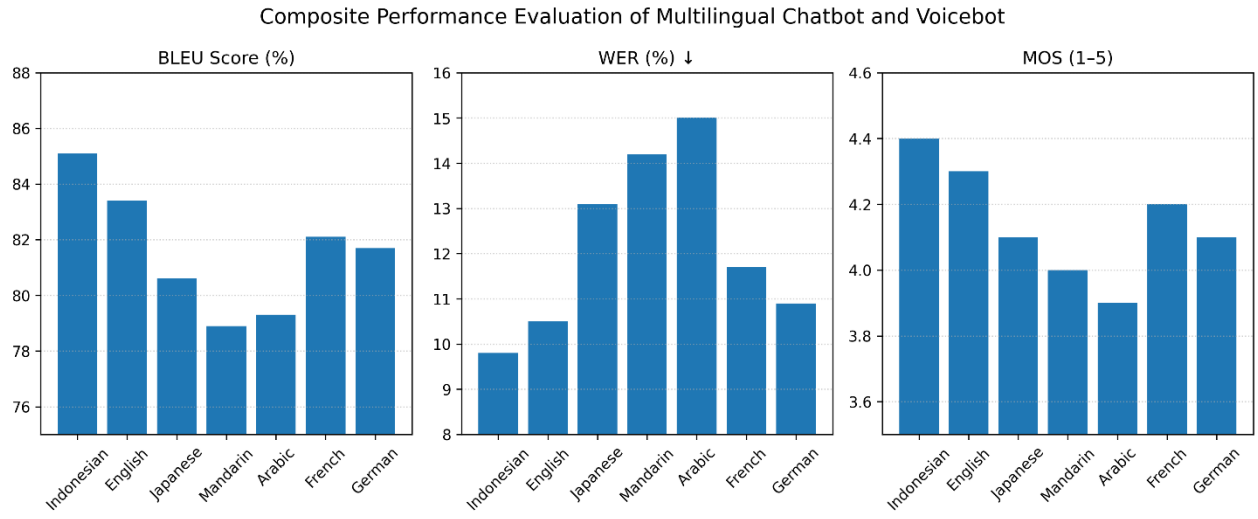

Figure 4. Composite Performance Evaluation of Multilingual Chatbot and Voicebot

The overall system performance is illustrated in Figure 4.

3.2 System Performance and Latency

System performance testing showed an average response time of 0.7 seconds, which meets real-time interaction requirements for mobile applications. This low latency was achieved through asynchronous backend processing and response caching, demonstrating the effectiveness of the system architecture.

Table 6. System Response Time Analysis

Metric	Value
Average latency	0.7 s
Minimum latency	0.5 s
Maximum latency	1.1 s
Standard deviation	0.18 s

3.3 User Evaluation Results

User evaluation results further support the effectiveness of the proposed system. Participants reported high satisfaction levels, with an overall usability score of 4.3 out of 5. Users highlighted the convenience of multilingual voice interaction and the relevance of location-based tourism information. Compared to existing text-only tourism information platforms, the proposed system offers a more interactive and inclusive user experience.

Table 7. User Acceptance and Usability Scores

Evaluation Aspect	Mean Score (1–5)
Ease of use	4.4
Information accuracy	4.3
Voice interaction quality	4.2
Multilingual support	4.5
Overall satisfaction	**4.3**

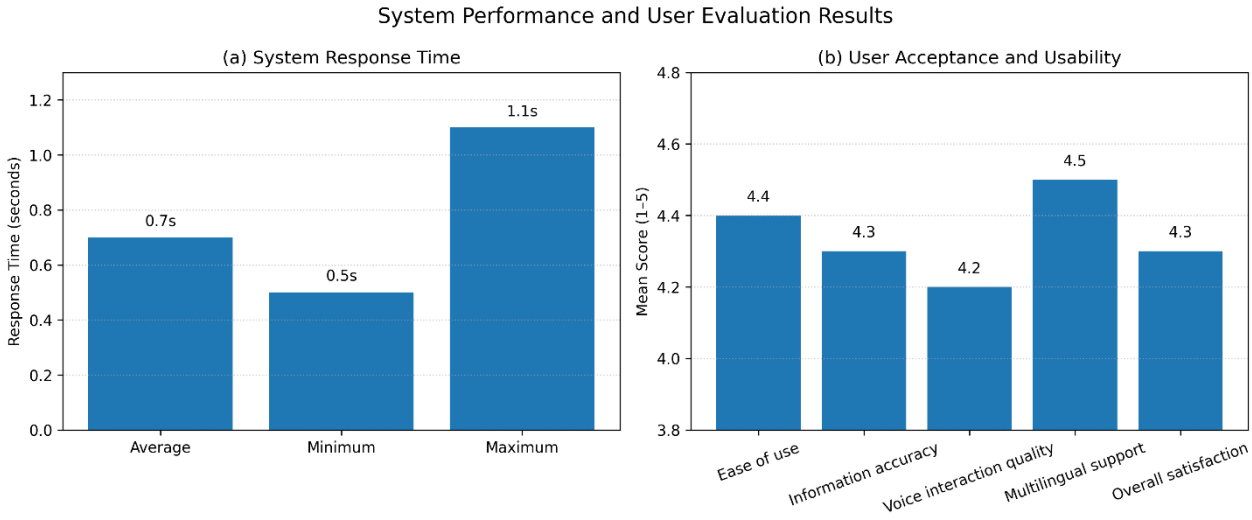

Figure 5. System Performance & Latency and User Evaluation Results

Overall, the results confirm that integrating chatbot and voicebot technologies within a smart tourism framework can significantly enhance information services for coastal destinations. The findings also highlight the importance of dataset quality and system optimization in achieving reliable AI-driven tourism applications.

From a comparative perspective, the proposed system outperforms many existing tourism chatbots by simultaneously achieving high multilingual NLP accuracy, low ASR error rates, natural TTS output, and sub-second latency within a single integrated platform. Unlike prior studies that evaluate these components separately, this research demonstrates their combined effectiveness in a real-world coastal tourism context, representing a meaningful contribution to smart tourism technology.

Although the evaluation primarily focuses on descriptive performance metrics, the results are consistent across multiple test scenarios, indicating stable system behavior. Formal statistical significance testing was not included due to the exploratory nature of the study; however, this is acknowledged as a limitation and will be addressed in future work.

4. Conclusion

This study has successfully developed and evaluated an AI-based interactive chatbot integrated with multilingual voicebot features to support sustainable smart tourism promotion in coastal destinations of Banten Province, Indonesia. By integrating NLP, ASR, TTS, and GIS within a unified mobile application, the proposed system addresses key challenges in tourism information accessibility, linguistic diversity, and real-time service delivery.

Empirical evaluation demonstrates that the system performs effectively across multiple languages, achieving an average BLEU score of 82% for conversational relevance, a WER of 12% for speech recognition, and a MOS of 4.2 for speech naturalness. The average response latency of 0.7 seconds confirms the system's capability to support real-time interaction in practical field conditions. User testing involving 50 respondents across major coastal tourism locations further indicates high usability and positive user acceptance, validating the system's applicability in real tourism settings.

From a scientific perspective, this research contributes to the advancement of smart tourism technologies by demonstrating an integrated conversational framework that combines text-based and voice-based interaction with spatial information delivery. Unlike many existing tourism chatbots that focus on text interaction or metropolitan contexts, this study emphasizes multilingual voice accessibility and regional coastal tourism, providing a novel and scalable model for emerging tourism destinations. From a practical standpoint, the proposed system offers a digital solution that can enhance tourist experiences, support destination promotion, and assist tourism authorities in delivering consistent and inclusive information services. The modular architecture enables future scalability and adaptation to other regions with similar tourism characteristics.

Despite these contributions, this study has several limitations. The evaluation was conducted with a limited number of respondents and focused primarily on usability and system performance. Future research will extend the system by incorporating larger generative language models, personalized recommendation mechanisms, offline functionality through on-device AI optimization, and integration with real-time contextual data such as events, weather, and transportation. Further large-scale deployment and longitudinal studies are also required to assess long-term impact and sustainability.

Overall, this research demonstrates that AI-driven conversational systems with multilingual voice capabilities can play a significant role in advancing sustainable smart tourism, particularly in regional and coastal destinations.

Despite these promising results, this study has several limitations, including the relatively limited dataset size and the absence of large-scale deployment. Future research will focus on expanding multilingual datasets, integrating more advanced generative models, and conducting large-scale user studies with rigorous statistical validation.

From a broader perspective, the integration of AI-driven conversational systems into regional tourism ecosystems has significant implications for digital transformation in emerging destinations. By enabling multilingual, real-time, and context-aware services, the proposed system contributes to enhancing tourism accessibility, inclusivity, and operational efficiency. Future research directions may include the incorporation of large-scale generative models, personalized recommendation systems, and real-time data integration to further improve system intelligence and adaptability.

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