Optimizing Ecotourism in North Taihu Lake, Wuxi City, China: Integrating Back Propagation Neural Networks and Ant-Colony Algorithm for Sustainable Route Planning

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Article Information	ABSTRACT
Article Type: Research Article **Corresponding Author:** **Siti Zubaidah Binti Mohd Ariffin** zubaidah.ariffin@fpe.upsi.edu.my https://orcid.org/0000-0001-6416-8601	Urbanization's rapid pace has sparked a growing interest in nature-based travel experiences, highlighting the growing importance of ecotourism. This study presents an innovative algorithm for ecotourism route planning, focusing on aligning tourists with attractions to enhance growth and appeal. The research utilizes ecological attractions in the Taihu Lake scenic area as an experimental dataset, incorporating historical travel data to examine the relationship between user characteristics and ecotourism attractions. Backpropagation neural networks and one-hot encoding are employed to predict visitor experiences. At the same time, a new ecotourism route design method combining deep learning and an ant colony algorithm based on average distance is applied to formulate an optimal ecotourism route. Results indicate Yuan Tou Zhu and Ling Shan as the top recommended destinations, with the optimal path identified as 1, 2, 3, 6, 4, 5, 7. This suggests that considering individual tourist preferences significantly elevates visitor satisfaction in ecotourism route planning, and it reveals the positive impact of aligning tourist attributes with attraction features. The findings underscore the importance of integrating user preferences into ecotourism planning strategies. Prioritizing personalized tourist experiences significantly enhances the effectiveness of ecotourism route planning initiatives. The research contributes a comprehensive framework for revitalizing ecotourism in the digital age, recommending the prioritization of individual tourist inclinations and attraction compatibility. Furthermore, adopting deep learning techniques and one-hot encoding is suggested to enhance the accuracy and efficacy of ecotourism planning. **Keywords:** Ecotourism; Ant-colony Algorithm; Deep Learning; One-hot Encoding; Visitor Satisfaction

1. INTRODUCTION

The International Ecotourism Association Society (TIES) defined ecotourism in 1991, describing it as a form of responsible travel to natural regions that aims to safeguard the environment and enhance the well-being of local communities (Pathak et al., 2023). The main idea of ecotourism encompasses several vital principles (Pathak et al., 2023).

Firstly, there is an emphasis on mitigating adverse effects on the environment. Secondly, ecotourism seeks to foster an understanding and appreciation of a destination's natural and cultural aspects. Furthermore, it aims to create a positive and enriching experience for visitors and residents. Additionally, ecotourism endeavors to generate direct economic gains by contributing to conservation efforts. Moreover, it strives to provide economic benefits and empower local communities (Hatma et al., 2022). Lastly, ecotourism aims to cultivate a heightened awareness and sensitivity towards the host country's political, environmental, and social dynamics. The Quebec Ecotourism Declaration, established in 2002, acknowledges the fundamental tenets of sustainable tourism regarding the economic, social, and environmental ramifications associated with tourism (Baloch et al., 2022). The proclamation stipulates that ecotourism should actively contribute to preserving both natural and cultural heritage. This entails the inclusion of local and indigenous populations in planning, developing, and operating ecotourism activities, aiming to enhance their overall welfare (Quintana, 2020).

The study on ecotourism in China was commenced in 1992. It has demonstrated significant advancements over the past three decades, including the conceptual understanding of ecotourism, its environmental implications, community involvement, and educational contributions (Rahman et al., 2022). The concept of ecological civilization, proposed and further developed at the 18th National Congress of the Communist Party of China, has led to a growing interest in ecotourism. Ecotourism, characterized by its environmentally friendly approach, minimal resource consumption, and emphasis on ecological sharing, aligns well with the principles of ecological civilization (Lin et al., 2022). As a result, the ecotourism market has experienced significant growth, leading to increased research and exploration of ecotourism theory and practice.

The eco-cultural tourism circuit in this study about Taihu Lake primarily comprises four towns: Suzhou, Wuxi, Changzhou, and Huzhou. These cities are intricately linked with other major urban centres such as Shanghai, Nanjing, Zhenjiang, Jiaxing, Hangzhou, and Ningbo. In recent years, these four cities have collaboratively organized the inaugural International Tourism Festival around Taihu Lake, the Yangtze River Delta Integrated Cultural Tourism Summit and the Cultural Tourism Industry Forum around Taihu Lake. Additionally, they have collectively introduced the cultural tourism brand "Ten Sights around Taihu Lake" and curated boutique routes featuring attractions such as Huzhou Taihu Dragon Dream, Nanxun Ancient Town, Changzhou Dinosaur Park, Yancheng in spring and autumn, Wuxi Nianhuawan Town, and Suzhou Taihu Lake. The objective is to collaboratively safeguard the advancement and establishment of Taihu Lake while concurrently fostering the growth of ecotourism in the surrounding area. Sustainable tourism encounters challenges related to a singular development model, limited product diversity, and a lack of core competitiveness (Rahman et al., 2022). Consequently, there is a need to boost customer satisfaction and service quality and strengthen the potential to drive economic growth in surrounding areas.

Meanwhile, with the advancement of information technology, there has been a growing trend among individuals to utilize online tourism platforms to plan their trip routes. This facilitates the ability of online platforms to further the promotion of ecotourism. However, suggesting tourist sites based on user preferences necessitates analyzing and manipulating a substantial volume of user feature data. When developing travel itineraries for consumers, it is imperative to carefully curate a selection of acceptable attractions from a vast array of options and construct a well-suited path. Many methodologies, including multiple linear regression, collaborative filtering, deep learning, matrix decomposition, and association rule learning, examine user characteristics and recommend attractions.

The travel route planning problem here is an NP (Non-deterministic Polynomial)-complex problem (Yahi et al., 2015). Utilizing a heuristic algorithm is a practical approach to resolving this challenge (Gavalas et al., 2015). Liang et al. (2021) use an ant colony algorithm to solve the trip planning problem considering distance and scenic spot comfort ratio. However, only some distinctive data analysis methodologies are available to develop a tourism recommendation system. Meanwhile, the travel planning algorithm needs to consider the degree of compatibility between attractions and travelers. This study presents a novel approach for ecotourism route planning by integrating deep learning and an ant colony algorithm.

This study aims to enhance the competitive edge of the Taihu Lake scenic area in ecotourism by proposing a novel ecotourism route design method that integrates deep learning and an ant colony algorithm. The effectiveness of this method is tested through its application in the tourism planning of the North Taihu Lake Scenic area. Integrating the recommendation factor, derived from the backpropagation (BP) neural network algorithm, into the iterative process of the ant colony algorithm is a crucial focus of this research. This integration underscores the inherent connection between visitors and attractions in Wuxi, fostering a tailored experience that heightens visitor satisfaction and reinforces the principles of ecotourism and sustainability. Combining these advanced techniques, the study seeks to provide a comprehensive approach to ecotourism route planning, prioritizing individual preferences and attraction compatibility. This contributes to the scenic area's attractiveness and aligns with the broader goals of promoting responsible and sustainable tourism practices. The validation of this methodology in the North Taihu Lake Scenic area emphasizes its potential applicability in real-world ecotourism planning scenarios.

2. LITERATURE REVIEW

The rising ecotourism sector has gained significant recognition within the tourism industry due to its capacity to promote sustainable economic development while preserving natural resources (Kiper, 2013). Nevertheless, despite its optimistic trajectory, ecotourism encounters numerous hurdles, particularly in the era of digital technology (Mileti et al., 2022). Route planning is a crucial element within the realm of ecotourism, attracting considerable interest from scholars on a global scale. Various studies have proposed different models and algorithms to address the challenges of personalized route planning in ecotourism. Lv (2022) designed an ecotourism personalized route planning system based on the ecological footprint model, considering the popularity of scenic spots and user preferences. Xie (2018) emphasized the importance of scientifically and rationally designed tourist routes to improve tourist satisfaction and promote the long-term development of tourist destinations, particularly in rural ecotourism.

Yan (2022) proposed an improved interest field travel route planning model to enhance the personalization of tourism route planning by considering tourists' interests and using an intelligent interest field extraction model. These studies highlight the significance of route planning in ecotourism and provide valuable insights into optimizing tourist routes based on various factors and preferences. This research aims to comprehensively examine the current body of literature on the challenges encountered in ecotourism, with a specific focus on the importance of route planning in its progression. This review will underscore the research deficiencies in the Wuxi tourist region, highlighting the relevance and urgency of the present study. A multitude of academics have extensively examined many obstacles encountered within the realm of ecotourism. Some researchers emphasize the inherent contradiction of increased tourism and the imperative to preserve the ecosystem (Zeng et al., 2022).

The growing need for genuine experiences threatens the fragile equilibrium of indigenous ecosystems. Another viewpoint pertains to the amalgamation of information technology and ecotourism. The advent of the information age has provided various technological advancements that can enhance the overall tourist experience. The amalgamation of information technology and ecotourism has the potential to enhance the overall tourist experience. The information age has brought about technological advancements that can be utilized in the tourism industry (Zainol et al., 2023). Information and communication technologies (ICTs) facilitate global communication between the travel industry's suppliers, consumers, and intermediaries (Li et al., 2023). Digital marketing strategies enabled by ICTs can be used to connect with tourists and provide them with diverse tour information and destination images (Khan et al., 2022). The use of ICT in tourism has revolutionized operations within the tourism distribution channel and has stimulated tourism in some countries, leading to further advancements in ICT (Bayrakci & Özcan, 2022). The use of ICTs, such as information and communication technologies, has significantly changed the dynamic nature of the tourist experience, allowing for increased consumer involvement and co-creation (Yetimoğlu, 2022).

Alharbe et al. (2023) present an algorithm for collaborative filtering that uses embeddings to recommend content to users by assessing similarity. The efficacy of the approach has been demonstrated. Oukawa et al. (2022) conducted a comparative analysis of multiple linear regression and random forest techniques for fine-scale modelling of urban heat islands. Nevertheless, these two approaches are better suited for scenarios involving a limited number of qualities. When the number of attributes exceeds a certain threshold, the accuracy of multiple linear regression fails to fulfil the desired criteria. Law et al. (2019) summarise the utilization of deep learning techniques in the context of travel demand forecasting. Subsequently, the researchers substantiate the efficacy of their proposed approach by presenting a case study involving travel to Macau. Association rule learning approaches are employed for pattern mining in tourism attraction (Versichele et al., 2014). During 15 days, 14 tourist sites and 14 hotels were monitored and recorded. The resulting data was then analyzed and visualized through visit pattern maps, effectively displaying the identified trends. Subsequently, the techniques for building a travel itinerary are presented.

The methods can be categorized into Exact Algorithms and Heuristic Algorithms. A summary of using the Dijkstra algorithm in the context of trip plan suggestions has been provided (Gunawan & Tho, 2021). The Dijkstra algorithm is a well-known and widely used precise method commonly employed to solve the travelling salesperson issue. However, the travel route planning problem is an (Non-deterministic Polynomial) NP-hard problem (Yahi et al., 2015). Utilizing a heuristic algorithm is a practical approach to resolving this challenge (Gavalas et al., 2015). Liang et al. (2021) use an ant colony algorithm to solve the trip planning problem considering distance and scenic spot comfort ratio. However, it is essential to acknowledge the potential problems of these advancements, as they may inadvertently dilute the fundamental principles of ecotourism, particularly the intimate connection with the natural environment.

2.1 Deep Learning on Scenic Spot

Neural networks, particularly back propagation networks, have been widely utilized in many recommendation systems (Ding et al., 2022). Forouzandeh et al. (2022) suggest a novel approach integrating an evolutionary algorithm with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) model. The individuals recommend tourist destinations based on their tastes and experiences.

An and Moon (2022) employ sentiment analysis with the Convolutional neural networks-long-short term memory (CNN-LSTM) approach to provide recommendations for tourist destinations. Nevertheless, managing high concurrency scenarios poses a significant challenge. Nuanmeesri (2022) hopes to enhance community tourism in emerging cities by employing gamification techniques to enhance the quality of tourist products and services in offline and online operations, presenting a comprehensive framework for community recommendations. Our study employs targeted and suitable methodologies within our suggestion framework to advance the cause of sustainable tourism and ecotourism.

2.2 Route Planning

The area of ecotourism encompasses two distinct sorts of route planning methods: automatic planning and interactive planning. Automatic planning is concerned with applying path optimization algorithms to autonomously choose the most efficient route for a user based on predefined objectives. On the other hand, interactive planning utilizes interactive features, allowing users to carefully devise a comprehensive itinerary by choosing preferred destinations and waypoints. The methodology described in this passage pertains to automatic planning algorithms. The problem of automatic route planning falls within the category of NP (Non-deterministic Polynomial) --hard problems within the field of path optimization (Tong et al., 2022). In order to address NP-hard issues, it is customary to employ optimization methods with a strong focus on heuristic algorithms. Heuristic algorithms can be classified into constructive and meta-heuristics (Pan et al., 2019). Constructive heuristics utilize iterative methods to incorporate nodes until a thorough solution is achieved gradually. This comprises methods that are based on approaches (Chvatal, 1979), graph creation methods (Phillips et al., 2015) and methods that involve region partitioning (Horn, 1995). Such algorithms are characteristically efficient.

Nevertheless, owing to structural constraints, they are susceptible to landing in local optima, rendering the solution quality often suboptimal. Meta-heuristic algorithms expand the search spectrum and continuously employ iterative mechanisms to refine and derive superior solutions. However, the temporal and spatial overheads they incur are frequently prohibitive. Prevalent meta-heuristic algorithms include Genetic Algorithms (GA) (Baker & Ayechew, 2003), ant colony algorithms (Li et al., 2022) and water drop algorithms. Because of the small scale of the problem described in this paper, meta-heuristic can better solve the problem.

Building upon the existing literature, this study identifies a research gap in ecotourism, specifically in integrating route planning methodologies with sustainable practices, community engagement, and tourist satisfaction. Existing studies often focus on algorithmic efficiency or optimizing the tourist experience but tend to overlook the fundamental objectives of ecotourism, such as environmental conservation and local community welfare. Furthermore, there needs to be more connection between ecotourism route planning and tourist satisfaction, which is crucial for enhancing the overall quality of the ecotourism experience and ensuring long-term success in sustainable tourism practices. This research aims to bridge these gaps by developing a comprehensive route planning approach that utilizes advanced algorithms and upholds principles of ecological preservation, community development, and visitor contentment.

3. METHODOLOGY

The approach described in this article can be divided into two components: employing a deep learning methodology for suggesting points of interest and formulating an ecotourism route by utilizing an ant

colony algorithm. This paper proposes a recommended method that utilizes Back Propagation Neural Networks (BPNN) as its underlying framework. The encoding approach utilized in this study is the one-hot method. It is imperative to adequately format and structure the data before training the neural network. Before analysis, the data must undergo a cleansing procedure to remove any irregularities and extreme values. Subsequently, encoding categorical features is necessary to make them comprehensible for the BP Neural Network. The One-Hot Encoding technique is widely employed in machine learning to manage categorical data. This technique is beneficial when dealing with categorical data, such as tourist preferences for specific types of destinations and past travel records, which cannot be directly fed into a neural network. No mathematical link can be observed between various categories, such that the summing of Category 1 and 2 does not yield Category 3. To effectively tackle the matter under consideration, the technique of One-Hot Encoding is employed. This methodology transforms categorical variables into a binary representation, including 0s and 1s. Using this methodology, neural networks can significantly augment their predictive capacities. To provide an example, consider a characteristic referred to as "preferred type of destination" that includes three separate classifications: "beaches," "mountains," and "forests." To characterize this attribute, it can be encoded into three binary columns, each corresponding to a distinct category.

3.1 BP Neural Network

BP Neural Networks are one of the primary neural networks in deep learning. The BP neural network is trained using historical data of tourists, including their preferences, travel history, feedback on visited places, and more. It includes input layers, hidden layers and output layers.

Input Layer: This consists of neurons equal to the number of features in our dataset. After being one-hot encoded, each feature represents an individual neuron.

Hidden Layers: Depending on the complexity of the data, we have one or more hidden layers. These layers capture intricate patterns in the data which might not be visible at the higher level.

Output Layer: It provides the list of recommended places of interest. The number of neurons here corresponds to the total number of tourist spots under consideration. Each neuron's activation level represents the recommendation score for a specific spot.

The distances between attractions are modified based on the recommendation ratings generated from the neural network as we integrate them into the Ant Colony Algorithm. Specifically, a high recommendation score can decrease the perceived distance, whilst a low recommendation score can magnify it. Making appropriate modifications guarantees that the recommended destinations will become more appealing to potential visitors, akin to ants in our analogy results and analysis.

4. RESULT AND DISCUSSION
4.1 Ant Colony Algorithm

Step1: Initialization:

At the start, each ant is placed in a randomly chosen place of interest. Pheromone levels on all paths are initialized to a constant value.

Step2: Pheromone Update and Path Selection:

As ants travel on the paths, they leave pheromones proportional to the recommendation score and inversely proportional to the distance. It means a shorter path between higher recommended places will accumulate pheromones faster. The probability P_{ij} of ant k moving from place i to place j is calculated and shown in Equation 1 (Lalbakhsh et al., 2013)

$$P_{ij}^k = \frac{\tau_{ij}^\alpha \times \eta_{ij}^\beta}{\Sigma \tau_{ik}^\alpha \times \eta_{ik}^\beta} \qquad (1)$$

Where:

τ_{ij}^α Represents the pheromone on the path between places i and j.

η_{ij}^β Represents the desirability of the move, which is calculated based on the effective distance.

α and β represent parameters that control the influence of pheromone and effective distance.

4.2 Pheromone Evaporation

Over time, pheromones on paths evaporate, simulating the volatile nature of pheromones in the real world. This ensures that the algorithm does not converge prematurely and that the solutions will not be trapped in local optimal solutions.

4.3 Experiment

Several ecological attractions within the Wuxi Taihu Lake Scenic Area have been chosen as the experimental dataset to ascertain the efficacy of the methods posited in this study. In the initial phase, data was collected about the following attractions: Yuan Tou Zhu, Ling Shan, Chang Guang Xi, Mei Yuan, Xi Hui Gong Yuan, Nian Hua Wan, and Li Yuan. Their latitudes and longitudes are shown in Table 1. Regarding tourist information, we assembled the following data points: historical travel data of tourists, demographics and preferences of the tourists, including age, salary, gender, educational background, commonly used modes of transportation, typical transportation costs, and preferred accommodations. Additionally, we acquired the driving route distances between these attractions, shown in Table 2. This was facilitated by utilizing the driving navigation API provided by Baidu Maps. The BP Neural Network trained the model using visitor data to forecast their preference levels for different sites. Comparative studies were undertaken to ascertain the one-hot encoding approach's efficacy. In the absence of one-hot encoding, a decrease in accuracy was seen with the progression of network training, suggesting the presence of mistakes in the training procedure. In contrast, following the implementation of one-hot encoding, the accuracy of predictions exhibited a progressive improvement during the training process, eventually reaching a notable degree of precision. Figure 1 illustrates the comparison between the two. Then, we introduce an additional analytical dimension that amalgamates the recommended level of each attraction with their respective distances, resulting in a composite metric termed the recommendation index weighted distance'. This metric is pivotal in modelling the tourist's itinerary choices, as it inherently gravitates towards attractions that are both highly recommended and in closer proximity.

This approach aligns with the psychological preferences of tourists, potentially augmenting their satisfaction with the ecological tourism experience. This outcome serves as evidence supporting the effectiveness of employing this particular strategy. Finally, the recommendation score of each place of interest is shown in Table 3. Solving with the ant colony algorithm, the optimal path is 1, 2, 3, 6, 4, 5, and 7, shown in Figure 2. In conclusion, implementing information technology and big data in ecotourism significantly alters the visitor experience and the operational framework of the industry. The optimization is conducted based on the following aspects:

(1) Customized travel experience: Most tourists are subjected to standardized and generalized recommendations within the conventional travel paradigm. However, by implementing informatization and utilizing big data, it has become feasible to offer personalized recommendations to individual visitors by considering their interests, travel history, and other pertinent data. This implies that individuals with a strong interest in bird watching may be advised to visit a nature reserve characterized by a diverse avian population instead of an area primarily focused on trekking activities. This greatly facilitates the advancement of ecotourism.

(2) Conservation of the biological environment: Specific recommendations can also facilitate improved management and allocation of visitor flows, thereby mitigating the impact on vulnerable ecological areas. For instance, if a particular region is undergoing ecological restoration or maintenance, the system can temporarily decrease its recommendations for that place until it is again deemed suitable for accommodating tourists.

(3) Novel marketing strategies: By leveraging extensive data analysis, ecotourism destinations can discern emerging market trends and potential avenues for devising inventive and focused marketing approaches. For instance, if the data indicates an increasing market demand for a specific ecological experience, the attraction might promptly adapt its promotional plan to cater to this desire.
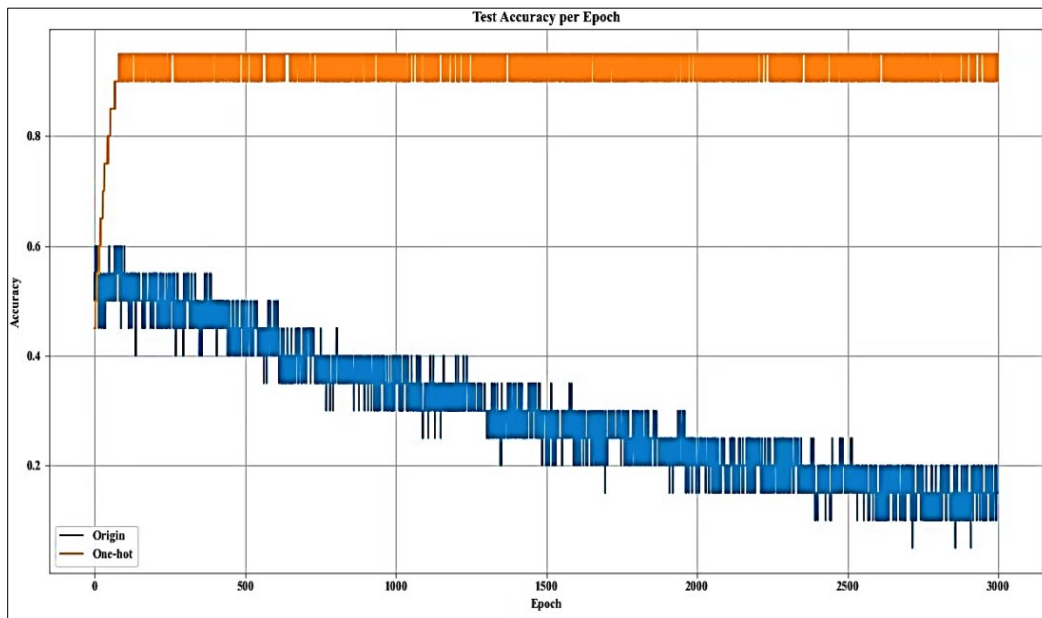
**Figure 1. Compared Training**

Table 1. Attractions List

No.	Attraction	Longitude	Latitude
1	Yuan to zhu	120.227995	31.517799
2	Chang guang xi	120. 268561	31. 470521
3	Ling shan	120. 31191	31. 491169
4	Mei yuan	120.226094	31.413655
5	Xi hui gong yuan	120.274968	31.556382
6	Nian hua wan	120.072299	31.577472
7	Li yuan	119.851	31.258125

Table 2. Details of Driving Distance Between Various Attractions

(km)	1	2	3	4	5	6	7
1	0	52.934	60.306	65.631	94.123	89.892	98.02
2	52.934	0	27.518	32.843	36.249	35.193	40.146
3	60.306	27.518	0	7.398	13.296	8.541	17.74
4	65.631	32.843	7.398	0	8.396	12.115	13.124
5	94.123	36.249	13.296	8.396	0	13.532	6.388
6	89.892	35.193	8.541	12.115	13.532	0	15.499
7	98.02	40.146	17.74	13.124	6.388	15.499	0

Table 3. Recommendation Score

No	Attraction	Score
1	Yuan tou zhu	0.95
2	Ling shan	0.95
3	Chang guang xi	0.4
4	Mei yuan	0.5
5	Xi hui gong yuan	0.8
6	Nian hua wan	0.6
7	Li yuan	0.4
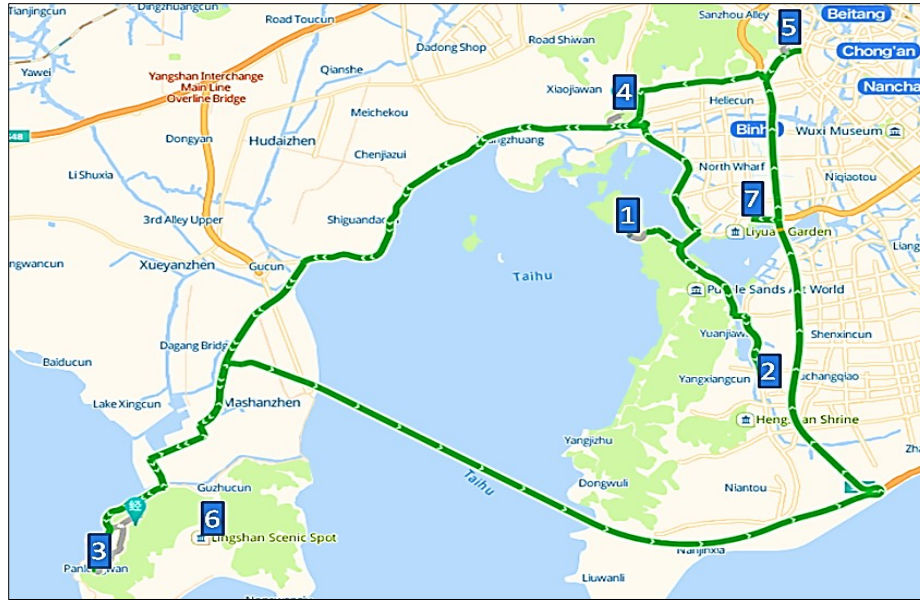
Figure 2. Travel Plan Result of North Taihu Lake

4.4 Discussion

Incorporating the comparative analysis with existing models and the synthesis of the proposed methodology into your original discussion enhances its depth and context. The simple shortest distance path planning scheme, without considering the satisfaction of tourists, may encounter unsatisfactory scenic spots at the beginning, and it is easier for tourists to directly terminate the trip, which is not conducive to the sustainable development of eco-tourism. In contrast, the path planning with recommendation index gives priority to the preference of tourists. Under the algorithm model of ant colony algorithm and the recommendation method of back propagation neural network as the underlying framework, the recommendation of scenic spots and historic sites is completed, which improves the accuracy and effectiveness of path planning, is the advantage of this study. In this paper, we propose a personalized travel route recommendation algorithm, which utilizes social scores and location scores of attractions based on crowd perception, as well as the driving distance between attractions, and the user's personal spatiotemporal accessibility value is integrated into this comprehensive score. This study tries to make the route planning of tourist attractions on the basis of tourist satisfaction. Previous studies have shown that tourists' preference for scenic spots has become an important factor in their choice of travel path and directly affects a pleasant travel experience.

In this study, constraints such as location point, user movement trajectory, and user preference are taken as constraints, and constraints are taken as influencing factors for path planning, which is obviously superior in path planning and it is consistent with previous studies (Liang et al., 2021).Comparative analyses with existing ecotourism models reveal that while many focus on individual aspects such as environmental conservation or economic development, few offer a holistic integration of these factors (Cabral & Dhar 2020). The proposed methodology's comprehensive approach, leveraging deep learning and ant colony algorithms, demonstrates superior efficacy in addressing the multifaceted nature of sustainable tourism.

This study also uses deep learning technology and one-hot encoding to significantly improve the effectiveness and accuracy of the ecotourism route planning plan. Finally, it plans the optimal tourism path, providing a comprehensive framework for revitalizing ecotourism in the digital age, consistent with previous studies (Li et al., 2022). In addition, ecotourism conforms to the concept of sustainable development and has excellent market development potential. Integrating technological innovations with ecotourism principles presents a robust framework for the sector's revitalization in the digital era. Our study's emphasis on integrating technological innovations with ecotourism principles reflects a broader commitment to sustainable development and showcases the market's vast potential. By prioritizing tourist satisfaction and leveraging the capabilities of advanced computational techniques, this study offers insightful perspectives on the potential of technology to revolutionize ecotourism, underscoring the importance of sustainable practices and personalized experiences in fostering a deeper connection between tourists and the natural world.

5. CONCLUSION AND RECOMMENDATIONS

This study explores the interconnection between ecotourism, advanced information technology, and travel recommendation systems in the context of Wuxi, a prominent tourist destination in China. This study presents an innovative approach combining deep learning and the Ant Colony Algorithm to optimize ecotourism route designs. Integrating the Ant Colony Algorithm with a recommendation factor based on the BP Neural Network facilitates a more profound synchronization between the tastes of tourists and the diverse range of attractions, particularly in locations such as Wuxi. This collaborative effort lays a significant emphasis on promoting the principles of sustainable tourism. In order to handle the non-numeric tourist data, the technique of One-Hot Encoding is employed, which improves the accuracy of recommendations. The primary focus of this study revolves around the experimental validation of the natural attractions inside the North Wuxi Taihu Lake Scenic Area. The system collects a wide range of data about attractions and tourist preferences, including various aspects such as demography, travel history, and other relevant factors. The driving distances for routes connecting these sites, particularly within Wuxi, are obtained from the driving navigation application programming interface (API) provided by Baidu Maps.

A significant discovery highlights the effectiveness of the one-hot encoding technique. Without its application, the model's training accuracy rapidly diminished. On the other hand, using this technique resulted in a consistent improvement in prediction accuracy. The study on encapsulation presents an innovative approach for developing ecotourism trip plans using deep learning and heuristic algorithms and sheds light on Wuxi's potential and contributions in this field. The ultimate objective is to provide accurate and tailored advice for tourists, thereby emphasizing and conserving Wuxi's cultural and historical assets for future generations.

Finally, adopting advanced technologies within the ecotourism sector is an enhancement and a necessity for modernizing and elevating the overall tourist experience. Our recommendation focuses on harnessing technologies such as deep learning algorithms, the Ant Colony Algorithm, and One-Hot Encoding to significantly improve the precision of travel recommendations, thereby ensuring that each tourist's experience is as rewarding and personalized as possible. The core advantage of integrating advanced technologies is their ability to process and analyze vast datasets, capturing nuanced tourist preferences and behaviors. By leveraging deep learning, stakeholders can develop systems that accurately predict individual preferences, offering recommendations that align with each visitor's unique interests and desires.

Tourists interested in serene, nature-centric activities could receive suggestions for tranquil lakeside spots or secluded nature trails rather than bustling urban centers. Advanced technologies enable the creation of dynamic, personalized travel itineraries that adapt to real-time feedback and changes in tourist preferences. This adaptability improves the tourist experience and boosts satisfaction by personally making tourists feel understood and valued. The application of algorithms like the Ant Colony Algorithm, which simulates decision-making like natural ant colonies, can optimize route planning in real time, ensuring that tourists can enjoy a seamless experience that maximizes their enjoyment and engagement with the destination

6. LIMITATIONS AND FUTURE STUDIES

The dataset used in this study is limited to the Taihu Lake scenic area located in Wuxi, China. Due to geographical constraint, the suggested ecotourism route planning algorithm may have limited applicability to other regions with distinct eco-attractions and tourist profiles. Furthermore, it is essential to note that the historical travel data utilized for research may not comprehensively encompass evolving travel patterns and preferences. This limitation could impact the algorithm's capacity to adapt effectively to shifting visitor behavior. Moreover, the research mainly utilized quantitative data while neglecting to thoroughly investigate qualitative dimensions, such as cultural, social, and economic determinants that impact ecotourism. Implementing in-depth qualitative analytical methods, such as interviews and surveys, can achieve a more comprehensive understanding of the aspects that influence ecotourism experiences. In addition, integrating real-time data and monitoring visitor behavior will enhance the advancement of dynamic and adaptive algorithms. Investigating the incorporation of developing technologies, like artificial intelligence and augmented reality, can offer inventive solutions for customized ecotourism experiences, going beyond the scope of deep learning. Collaborative research across many fields, such as ecology, sociology, and technology, enhances our awareness of the various aspects of the changing digital era that affect the planning of ecotourism routes.

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