Entertainment Computing 52 (2025) 100829

Contents lists available at ScienceDirect

Entertainment Computing

journal homepage: www.elsevier.com/locate/entcom

Intelligent entertainment robots based on path navigation planning in tourism intelligent services and user entertainment experience analysis

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ARTICLE INFO

Keywords:
Path navigation planning
Intelligent entertainment robot
Tourism intelligent service
User entertainment experience

ABSTRACT

With the development of tourism industry, users have higher and higher demand for travel experience, while traditional tourism services can no longer meet the needs of users. Therefore, as an innovative tourism service mode, intelligent entertainment robots have broad application prospects. This paper proposes a design scheme of intelligent entertainment robot based on path planning. By combining navigation technology and entertainment functions, intelligent entertainment robot can provide customized travel and entertainment services for users according to their needs and interests. By collecting the geographic information of the tourist scene and the user's preference data, the path planning algorithm and machine learning technology are used to determine the robot's cruise path and entertainment recommendation. At the same time, it also uses computer vision technology and emotion recognition technology to perceive and analyze the user's emotional state, so as to provide a more personalized entertainment experience. The experimental results show that under the guidance and recommendation of intelligent entertainment robots, users' travel experience has been significantly improved, and users' satisfaction with tourism services and pleasure of entertainment experience have been improved.

1. Introduction

With the development of society and the improvement of people's living standard, tourism has become a widely popular activity. However, there are some problems in the traditional way of tourism, such as inconvenient access to information, insufficient guide, monotonous travel process, etc., which leads to the user's travel experience can not be fully satisfied. Therefore, it has become an urgent need to improve users' travel experience and enhance the quality of tourism intelligent services. Whether it is tourism or daily travel, people hope to enjoy high-quality and efficient travel services. In this context, smart travel has become the focus of people's attention. As an important component of smart travel, path planning systems are playing an increasingly important role. The path planning system can provide convenient ways for people to travel. Through intelligent navigation, traffic management, logistics delivery and other methods, path planning systems can provide people with the optimal path and transportation mode, making travel more convenient and efficient. For example, the emergence of online ride hailing, shared bicycles and other modes of transportation cannot be separated from the support of path planning systems. The path planning system can enhance people's travel experience. By perceiving and analyzing data such as environment and traffic conditions, path planning systems can provide personalized travel plans and services for people, making travel safer, more comfortable, and enjoyable. For example, the development of emerging businesses such as intelligent tourism applications and self-service travel cannot do without the support of path planning systems. The path planning system can promote the development of the transportation industry. With the increase in population mobility and the continuous release of tourism consumption demand, the pressure on the transportation industry is also becoming increasingly enormous. The application of path planning systems can improve the efficiency and safety of transportation, reduce operating costs and management difficulties, and further promote the development of the transportation industry.

The development of path planning systems cannot be separated from the collaborative cooperation of multiple disciplines. The path planning system involves multiple fields such as perception, memory, exploration, and optimization, with the support and collaboration of various professional technologies. For example, the interdisciplinary integration of artificial intelligence, data mining, transportation engineering, and

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https://doi.org/10.1016/j.entcom.2024.100829
Received 6 June 2024; Received in revised form 10 July 2024; Accepted 14 July 2024
Available online 15 July 2024
1875-9521/

other disciplines provides strong support for the development of path planning systems. These applications can provide users with travel planning, displaying congested road sections, avoiding obstacle sections, real-time navigation and other related services, but the safety and comfort of routes are still difficult to fully guarantee. In recent years, intelligent entertainment robots, as a new technology application, have been gradually applied in the field of tourism. Intelligent entertainment robot with its intelligent, interactive and entertainment characteristics, for tourists to provide a new travel experience. The entertainment robot can interact with users in a humanized way, provide customized tourism entertainment services, and present users with rich and diverse tourism content through multimedia forms such as voice, image and video, so that the travel process of users is more interesting, beneficial and pleasant. However, the research on tourism intelligent service and user entertainment experience is still relatively limited. The current intelligent entertainment robot mainly focuses on the realization of functions and technologies, while the analysis and evaluation of user entertainment experience are relatively lacking. Therefore, it is necessary to conduct in-depth research and analysis on the intelligent entertainment robot based on path navigation planning in terms of tourism intelligent services and user entertainment experience, so as to promote the development of tourism intelligent services and improve users' travel experience. Therefore, the research of intelligent entertainment robot based on path navigation planning has important practical significance and application value in the aspects of tourism intelligent service and user entertainment experience. By studying the design and application of intelligent entertainment robot, it can provide theoretical and practical support for improving users' travel experience and improving the quality of tourism intelligent service.

To address the above issues, this article proposes an intelligent tourism path planning and navigation optimization system based on data mining and GIS technology. The system can adopt exploration and utilization methods to continuously improve its own strategies, thereby obtaining optimization solutions, making autonomous route planning in unknown environments, and providing better travel services. The system mainly consists of two parts: data mining and GIS technology. In terms of data mining, the system will collect and analyze a large amount of travel data, including travel time, travel mode, travel route, etc. By analyzing and mining these data, the system can understand users' travel habits and needs, thereby providing more personalized travel plans. In terms of GIS technology, the system can utilize map data and GPS positioning technology to achieve real-time navigation and route planning. The system can also continuously improve its own strategies and obtain more optimized travel plans through continuous trial and error and learning. Therefore, the intelligent tourism path planning and navigation optimization system based on data mining and GIS technology in this article can provide users with more personalized, safe, convenient, and comfortable travel services, solve the current safety and comfort problems in travel, and improve overall travel satisfaction.

2. Related work

In the process of mobile positioning of tourists in scenic areas, in order to meet the unique positioning needs of tourists, the literature adopts the regional division positioning method, dividing the scenic area into sub areas based on readers, and conducting preliminary tourist zoning positioningShang et al. [1]. Drawing on the layout method of base stations from the cellular mobile communication system, it is applied to the reader layout of the LANDMARC positioning system, A hexagonal reader layout structure resembling a cellular network has been designed [2]. In the layout structure of the literature reader, the reader is arranged at the center of the regular hexagon, forming a compact and efficient layout form. This layout structure can reduce the number of readers within the coverage range, reduce system costs, reduce the overlap area of readers, reduce signal interference between readers during positioning, and improve positioning efficiency [3]. In the path planning problem of scenic spots, the heuristic factors and pheromone update rules of traditional ant colony algorithms are difficult to meet the needs of tourists' travel preferences and time constraints. In order to solve this problem, the literature combines the traffic volume of scenic spots and tourist preferences obtained by the LANDMARC positioning system to improve the traditional ant colony algorithm and design a path planning algorithm with the shortest time as the optimization objective [4]. In the literature, heuristic factors and pheromone update rules have been redesigned to better consider tourists' travel preferences and time constraints [5]. The heuristic factor is given higher weights, making ants more inclined to choose paths that match tourist preferences. At the same time, the pheromone update rules have also been adjusted, making the pheromone concentration on the path more susceptible to the influence of traffic and tourist preferences.

In response to the problem of urban safety path planning, the literature proposes a Q-learning safety path planning algorithm based on policy guidance mechanism [6]. This algorithm incorporates the safety index into the reward function for evaluating the quality of intelligent agent decision-making, in order to optimize safety and short-term goals. Specifically, the algorithm uses the average safety distance to represent the safety index of streets and intersections, and combines the safety index of the two locations to construct a reward function for a single step path. Through continuous interaction between intelligent agents and the environment, the task of finding secure paths is ultimately achieved. The literature proposes a strategy guidance mechanism based on artificial potential field functions [7]. This mechanism adds the target position as a prior information to the exploration strategy, increasing the probability of guiding the action to be selected, thereby accelerating the convergence speed of the algorithm [8]. The experimental results show that the safety and short distance comprehensive performance of the algorithm's path planning results are superior to the SafePath method currently used for urban safety path planning. To adapt to the reinforcement learning Actor-Critic framework, the literature proposes a CL evaluation network constructed with two LSTM units and two fully connected layers. In the literature, path length is a key component of the reward function [9]. Firstly, initialize the A-Ptr network parameters through label data pre training, then use the CL network to estimate the V value, and finally achieve the goal of optimizing network performance through interactive sampling and reinforcement learning training [10].

The literature has studied the development process and current problems of self-service tour guide devices, and combined with the personalized and experiential needs of tourists during travel, a self-service and intelligent Android mobile intelligent travel path planning and navigation optimization system has been designed by comprehensively utilizing technologies such as location positioning, electronic map services, location services, and geospatial databases [11]. The design of the literature system aims to meet the actual needs of tourists during the travel process, providing intelligent travel path planning and navigation services for tourists [12]. The system adopts technology based on location positioning and geographic information services, which can accurately obtain the current location of tourists and provide real-time navigation services. In order to ensure the accuracy and real-time of navigation, the system also utilizes technical means such as electronic map services and location services, which can provide tourists with detailed map information and introductions to surrounding scenic spots [13]. The literature system introduces technologies such as geospatial databases, which can provide personalized and experiential tourism route planning and navigation services for tourists [14]. Tourists can freely choose their travel routes and attractions based on their interests and preferences. The system will intelligently generate the optimal travel route and provide detailed navigation services based on the tourists' choices and current location, providing them with a better travel experience. The experimental results show that the system can effectively meet the personalized and experiential needs of tourists during travel, provide intelligent travel path planning and navigation services, and provide tourists with a higher quality travel experience

[15]. This system has broad application prospects in the tourism industry, and can bring a more intelligent, convenient, and comfortable service experience to the tourism industry.

3. Research on data mining algorithms based on GIS database

3.1. Spatial association rule mining algorithm

By integrating path navigation planning technology, the entertainment robot can provide users with personalized travel guidance and entertainment content recommendation. Through interactive communication with users, entertainment robots can provide targeted travel advice and entertainment arrangements according to users' interests, preferences and needs. For example, in the scenic spot guide process, the entertainment robot can make path planning according to the user's location and time, guide the user to visit the scenic spots of interest, and provide a wealth of relevant knowledge and interesting interactive games. Entertainment robots can also engage in intelligent conversations with users through speech recognition and natural language processing technology to provide them with instant entertainment services. Whether answering questions posed by users or engaging in a lighthearted chat with users, entertainment robots are able to interact with users in a friendly and approachable way, enhancing user immersion and engagement. In terms of user entertainment experience, the introduction of entertainment robots can provide users with personalized and diversified entertainment experience, and effectively enrich the entertainment content in the process of tourism. By providing a rich variety of entertainment options, such as music, games, story explanation, etc., entertainment robots can meet the entertainment needs of different users, and enhance the interest and enthusiasm of users to participate in tourism. The interactive and personalized services of entertainment robots also enable users to feel a unique experience, adding fun and memory value during travel.

Formal concept analysis is a mathematical method based on case theory and set theory, which aims to formalize the expression and processing of concepts. By analyzing and comparing the denotation and connotation of concepts, we can establish the relationship between concepts, such as generalization and specialization, and form the concept lattice.

In the power sets P(G) and P(M), two mappings α and β can be defined, called the Galois connection between the power sets of G and M:

$$\begin{aligned}\forall O_1 \subseteq O: \alpha(O_1) = \{d \in D \mid \forall o \in M(oRd)\}\\ \forall D_1 \subseteq D: \beta(D_1) = \{o \in O \mid \forall d \in N(oRd)\}\end{aligned} \tag{1}$$

The relationship between formal concepts is:

$$H_1 = (O_1, D_1) \prec H_2 = (O_2, D_2) \tag{2}$$

Among them:

$$O_1 \subseteq O_2, D_1 \supseteq D_2 \tag{3}$$

Support can be calculated using the following formula:

$$sup(X \Rightarrow Y) = P(X \cup Y) \tag{4}$$

$$conf(X \Rightarrow Y) = P(X|Y) \tag{5}$$

Spatial database refers to a database stored and managed in a spatial environment, which contains spatial features and location information. The probability of participation (PR) is an indicator used to measure the intensity of the influence of a spatial feature in a co location pattern. Formula (6) represents the calculation method of participation probability:

$$pr(c, f_i) = \frac{\left|\pi_{f_i} table\_instance(c)\right|}{|instance(f_i)|} \tag{6}$$

The participation index (pi) is used to measure the importance of a spatial feature in a parity pattern. Assuming that c is some spatial feature, formula (7) shows the calculation method of the participating index:

$$pi(c) = \min_{i=1}^{k} pr(c, f_i) \tag{7}$$

If there exist two equivalence modes C and C', the condition C ⊆ C' is satisfied, and the spatial feature C' in c' is the superset of some spatial feature C in c:

$$pr(c, f_i) \geq pr(c', f_i) \tag{8}$$

$$pi(c) \geq pi(c') \tag{9}$$

3.2. The process of spatial data clustering analysis

Spatial cluster analysis is used to discover grouping patterns and spatial structures in spatial data. It is the extension of cluster analysis in spatial database, using distance calculation and clustering algorithm to divide spatial objects into different clusters, so as to facilitate the analysis and utilization of spatial data. In the spatial clustering analysis, the appropriate distance measurement methods are selected first, such as Euclidean distance, Manhattan distance, Chebyshev distance, etc., to calculate the distance between spatial objects. Then, appropriate clustering algorithms are selected, such as hierarchical clustering, K-means clustering, DBSCAN clustering, etc., to divide spatial objects into different clusters. The determination of the number of clusters is an important step, which can be adjusted by observing the data distribution and experimental results. After executing the clustering algorithm, we can use internal evaluation index and external evaluation index to evaluate the clustering result. Internal evaluation indicators are used to evaluate the quality of clustering results, such as clustering tightness, clustering separation, etc., while external evaluation indicators are used to compare clustering results with actual categories, such as accuracy, recall rate, etc.

Euclidean distance is the most commonly used distance calculation method, which is calculated by the Euclidean distance between two space points, namely formula (10):

$$\begin{aligned}d(i,j) &= \sqrt{\sum_{k=1}^{m} \left|x_{ik} - x_{jk}\right|^2}\\ &= \sqrt{\left|x_{i1} - x_{j1}\right|^2 + \left|x_{i2} - x_{j2}\right|^2 + \cdots + \left|x_{im} - x_{jm}\right|^2}\end{aligned} \tag{10}$$

Calculate the Manhattan distance between two spatial points using formula (11):

$$d(i,j) = \sum_{k=1}^{m} \left|x_{ik} - x_{jk}\right| = \left|x_{i1} - x_{j1}\right| + \left|x_{i2} - x_{j2}\right| + \cdots + \left|x_{im} - x_{jm}\right| \tag{11}$$

The Minkowski distance is a generalized form of the Euclidean distance and the Manhattan distance, as shown in formula (12):

$$\begin{aligned}d(i,j) &= \sqrt[q]{\sum_{k=1}^{m} \left|x_{ik} - x_{jk}\right|^q}\\ &= \sqrt{\left|x_{i1} - x_{j1}\right|^q + \left|x_{i2} - x_{j2}\right|^q + \cdots + \left|x_{im} - x_{jm}\right|^q}\end{aligned} \tag{12}$$

Calculate the degree of dissimilarity between object i and object j using formula (13), namely:

$$d(i,j) = \frac{b + c}{a + b + c + d} \tag{13}$$

Calculate the degree of dissimilarity between object i and object j using formula (14), namely:

$$d(i,j) = \frac{b + c}{a + b + c} \tag{14}$$

3.3. Embedded integrated mining framework

Loose coupling is an external spatial data mining mode, in which a geographic information system is viewed as a simple spatial database, and the work of spatial data mining is carried out outside the environment of the geographic information system, usually through other software or computer languages, and the relationship between the two is established through data communication. The main feature of this model is its strong independence, allowing for the development of relatively universal spatial data mining systems independently, without relying on the GIS system itself.

In the field of tourism intelligent services and user entertainment experience, the concept of loose coupling can also be applied to the design and development of intelligent entertainment robots. As an entertainment service tool, intelligent entertainment robot is loosely coupled with geographic information system and tourism data, so as to provide users with personalized entertainment experience. Through the data communication with the geographic information system, the intelligent entertainment robot can obtain a variety of tourism-related information, such as scenic spot introduction, real-time road conditions, surrounding food, etc., so as to provide users with more comprehensive and practical entertainment services. At the same time, intelligent entertainment robots can also use the data of geographic information system for path navigation planning, to provide users with guidance and recommendations for travel guidance. Intelligent entertainment robots can also interact with other software or computer languages to enhance the user's entertainment experience. For example, intelligent entertainment robots can be combined with music playback software to automatically play the corresponding music according to the user's preferences and the current travel scene, creating a comfortable and pleasant atmosphere. In addition, intelligent entertainment robots can also provide a series of interesting games through interaction with game software, increasing the entertainment and interactive experience of users during travel. The loosely coupled design concept enables the intelligent entertainment robot to have a high degree of independence and versatility, and can independently develop and update entertainment functions without relying on a specific version or structure of the geographic information system. This mode makes the entertainment robot have better flexibility and adaptability, and can match with different tourism scenes and user needs, and provide users with personalized and diversified entertainment experience.

However, the loosely coupled pattern has some limitations in spatial data mining. Due to the fact that geographic information systems are only regarded as a simple spatial database rather than a complex spatial data processing system, their spatial data processing functions are usually limited, making it difficult to conduct in-depth mining and discovery of spatial data. Due to the fact that spatial data mining work is carried out outside the environment of geographic information systems, data communication can increase the complexity and operational costs of the system, and may also affect the efficiency and accuracy of data mining. Loosely coupled patterns often only achieve the basic functions of spatial data mining algorithms, and cannot optimize and expand algorithms, nor integrate with other data mining technologies. Therefore, they may be limited when dealing with complex spatial data mining problems.

Embedded mode is an internal spatial data mining mode that embeds spatial data miners as a module into geographic information systems. In this mode, the data mining system is fully integrated into the GIS system, which can fully utilize the various functions of the GIS system. Firstly, relevant data is obtained from the GIS database through the query function of GIS, and then spatial data mining tools are used to mine the hidden patterns in these data. These patterns are used for decision-making guidance and the establishment of expert knowledge bases, thereby establishing a more intelligent geographic information system. This mode greatly reduces the workload of development and reduces the difficulty of development. As shown in Fig. 1, the main advantage of embedded mode compared to loosely coupled mode is that it can fully utilize various functions of GIS systems, such as data query, data visualization, data analysis, etc., thereby improving the efficiency and accuracy of data mining. In addition, embedded mode can also achieve deep integration of GIS systems, allowing data mining results to directly affect the operation of GIS systems. But embedded mode also has some limitations. Firstly, due to the embedding of data mining systems into GIS systems, it is difficult to transplant them to other GIS systems, which has certain limitations. Secondly, due to the professional skills and resource investment required for the development and maintenance of data mining systems, it may increase the development and operational costs of the system.

The main feature of hybrid integration is the combination of loose coupling and embedded. In loose coupling, the data mining system and GIS system are independent and interact with each other through interfaces. In embedded systems, data mining systems are directly embedded into GIS systems and closely integrated with them. The hybrid integrated approach combines the advantages of two modes, which can maintain the flexibility and independence of data mining systems while fully utilizing the functionality of GIS systems. The

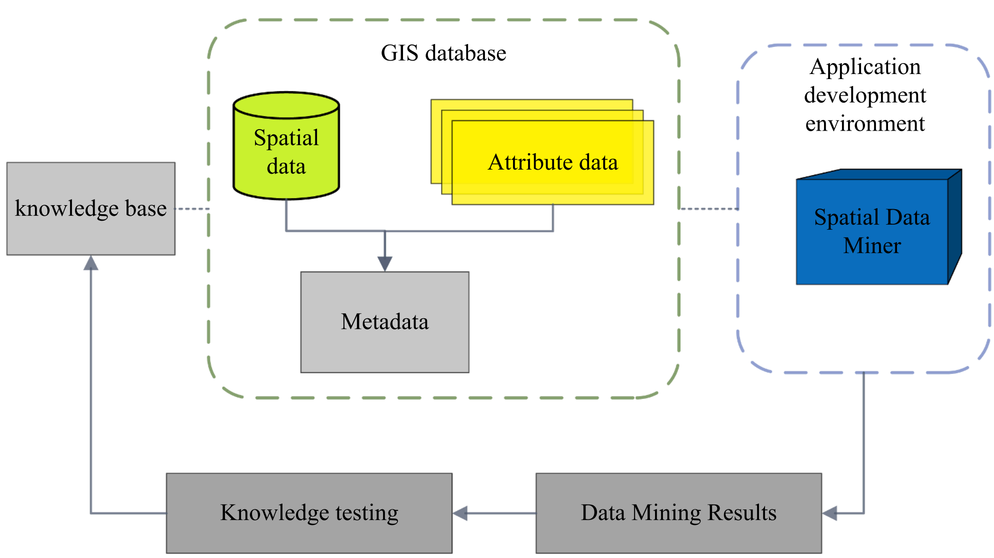

Fig. 1. Embedded Integration Framework.

advantage of adopting a hybrid integrated approach is that it can maximize the utilization of various functions of GIS systems, such as map visualization, spatial analysis, etc. At the same time, hybrid integration can also reduce the difficulty and complexity of self-development. By tightly integrating with GIS systems, data mining systems can directly utilize existing functions and data in GIS systems, avoiding repetitive development and maintenance work. This can save time and resources, and improve the efficiency and reliability of the system.

3.4. Analysis of comprehensiveness and correctness

Comprehensivity refers to the ability to discover all appositive patterns. The appositive pattern refers to all subsequences that have appeared in one sequence, and they appear in the same position in other sequences. Therefore, the mining of appositive patterns considers all possible subsequences to ensure that the mining results are comprehensive. Compared to traditional frequent pattern mining algorithms, appositive pattern mining algorithms consider the special properties of sequences in more detail to fully explore all possible appositive patterns.

Correctness refers to the fact that the participating index values of all mined in-place patterns are greater than or equal to the participating index threshold. Participatory index refers to the position where the same pattern appears in each sequence, and the threshold for participating index refers to the minimum number of occurrences of the same pattern in all sequences. Therefore, the correct result can only be considered when the number of occurrences of the same pattern in all sequences is greater than or equal to the participating index threshold. This requirement ensures the accuracy and reliability of the mining results, avoiding situations of misjudgment and omission.

The dynamic upper bounds of the participation of the same position pattern in the index will not result in the correct same position pattern being removed during the pruning process. This is because there is a certain relationship between the dynamic upper bound and the participating index, which can be calculated using formula (15):

$$prev(C) = \min_{\forall f_i \in C} pr(f_i, C) \le \min_{\forall f_i \in C} \overline{pr(f_i, C)} = \overline{prev(C)} \tag{15}$$

When the algorithm detects all instances of the same pattern, when the participating index value is 0, the dynamic upper bound is formula (16), which means no pruning is performed:

$$\left|S_i^i(C)\right| = \left|\{o \in S_i | \exists I \in IS(C) s.t.o \in I\}\right| \tag{16}$$

A series of experiments were conducted to verify the effectiveness of this algorithm. Firstly, the impact of partition edge length on algorithm execution time was tested. The results obtained by gradually changing the size of the partition edge length while using default values for other parameters are shown in Fig. 2.

By dividing spatial data into several small spatial units, the entire space can be divided into several small subspaces when processing spatial data, thereby reducing the complexity of the algorithm and improving its execution efficiency. In co location pattern mining, spatial partitioning is also widely used. The edge length of spatial partitions determines the granularity of spatial data partitioning and is closely related to the execution efficiency of algorithms. As shown in Fig. 3, the size of the edge length has a significant impact on the execution time of the algorithm. On the one hand, the larger the edge length, the less subspaces the spatial data will be divided into, which can reduce the complexity of instance detection and save algorithm execution time. On the other hand, the larger the edge length, the smaller the significance of participating in the upper boundary of the index, and the smaller the role of pruning. Therefore, considering these two factors when selecting the edge length, finding a suitable edge length can not only save the execution time of the algorithm, but also ensure the correctness and effectiveness of the algorithm.

In co location pattern mining, the number of instances and the number of spatial features are important factors that affect the efficiency of the algorithm. From Fig. 3, it can be seen that when the number of instances is small, the efficiency difference of the three methods is not significant. This is because when the number of instances is small, the execution time of the algorithm is mainly affected by the time cost of data reading and processing, and is not significantly related to the complexity of the algorithm itself. As the number of instances increases, the execution time of the algorithm is gradually affected by the complexity of the algorithm itself, and the advantages of Method 2 and Method 3 become increasingly prominent. As the number of spatial features increases, the execution time of the algorithm also increases. This is because increasing the number of spatial features increases the complexity of instance matching, leading to a decrease in the efficiency of the algorithm. However, compared to Method 1, Method 2 and Method 3 have a certain tolerance for increasing the number of spatial features, as they both introduce certain pruning techniques that can effectively reduce unnecessary calculations and reduce the complexity of instance matching. Especially with the help of spatial partitioning technology, method three can better utilize the distribution characteristics of spatial data, reduce instance detection time, and further improve the execution efficiency of the algorithm.

In collaborative positioning pattern mining, the number of instances and the number of spatial features are important factors affecting the efficiency of the algorithm. The intelligent entertainment robot aims at interactive entertainment and aims to enhance the user's travel experience. By using advanced technologies such as voice recognition and face recognition, intelligent entertainment robots are able to have a natural and smooth dialogue with users and provide personalized entertainment suggestions based on users' interests and preferences. For example, it can recommend suitable music playlists for users based on their music preferences, or provide challenging and fun games based on users' gaming preferences. In terms of user experience, the presence of intelligent entertainment robots makes the travel process more interesting and rich. Through interaction with intelligent entertainment robots, users can get detailed introductions of tourist attractions, recommendations of featured activities, and even take photos and videos

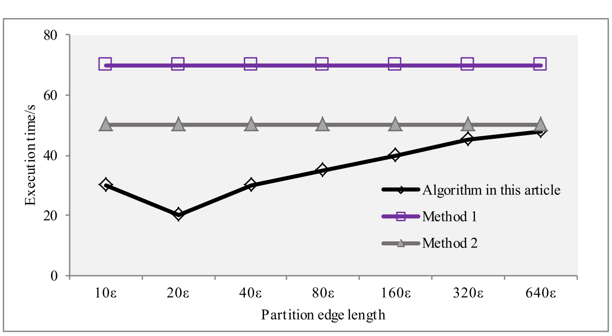

Fig. 2. Impact of spatial partition edge length on execution time.

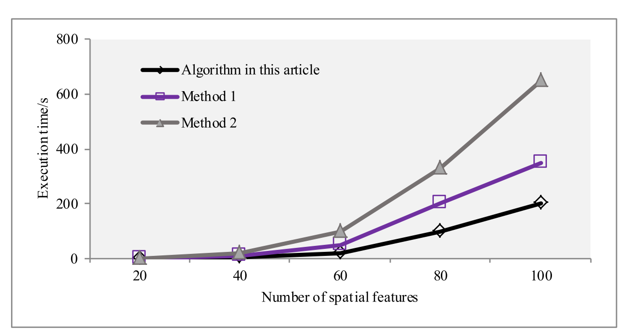

Fig. 3. The impact of the number of spatial features on execution time.

with the assistance of robots. In this way, users are not only observers of tourism, but also participants, who can have a deeper understanding of the historical and cultural background of tourist attractions, and can independently choose their own interesting entertainment activities, which improves the personalization and participation of tourism. In the process of collaborative positioning pattern mining, intelligent entertainment robots can also play an important role. It can provide users with location-specific entertainment recommendations based on the user's location information and navigation path, such as recommending nearby specialty snacks, shopping centers or entertainment venues. In this way, users can not only enjoy the beauty of tourist attractions, but also experience the local characteristics of culture and food, enhancing the comprehensive experience of tourism.

4. Design of intelligent tourism path planning and navigation optimization system

4.1. Modeling of multi-objective point path planning optimization problem

Distance is a commonly used concept in tourism planning, transportation planning, and other fields. It refers to the actual distance between two scenic spots, usually measured in kilometers (km). In calculating the distance between scenic spots, latitude and longitude information is often used because latitude and longitude can accurately represent the position of any point on Earth. In the latitude and longitude set, 1 represents longitude and 2 represents latitude. Longitude refers to the angle between a point on the Earth's surface and the Prime Meridian, ranging from −180 degrees to 180 degrees, where 0 degrees represents the Prime Meridian, with East longitude being positive and West longitude being negative. Latitude refers to the distance from a point on the Earth's surface to the equator, ranging from −90 degrees to 90 degrees, where 0 degrees represents the equator, with north latitude being positive and south latitude being negative.

Spot refers to a scenic spot or scenic area in a tourist area that has certain ornamental value, historical and cultural value, natural scenery value, etc. In the city cluster M, scenic spots are distributed among various cities. When tourists visit scenic spots, determining the starting and ending positions of the tour can help plan the tour route and time.

Assuming there are n scenic spots to visit, the mathematical formula for the shortest path is formula (17):

$$minz = \sum_{i\in M}\sum_{j\in M} Dist_{ij}\cdot x_{ij} \tag{17}$$

Constraint one is the travel cost constraint, which is formula (18):

$$TC = \sum_{i,j=1}^{n} LC_{ij}x_{ij} \le TC_{max} \tag{18}$$

Formula (19) represents the upper limit of travel expenses set by tourists.

$$\forall i \in M : TC_i \le TC_{max} + \left(LC_{fi} - TC_{max}\right)\cdot x_{fi} \tag{19}$$

Formula (20) indicates that the product of the midway cost from attraction i to attraction j and the travel time cannot exceed the travel cost limit set by the tourist.

$$Cost(Rr) = min\frac{(TC_{max} - TC)}{TC_{max}} \tag{20}$$

Constraint (2) is the travel time constraint, which is formula (21):

$$TT = \sum_{i=1}^{n} ST_i x_i + \sum_{i,j=1}^{n} LT_{ij}x_{ij} \le TT_{max} \tag{21}$$

Formula (22) indicates that the time from attraction i to attraction j cannot exceed the travel time limit set by tourists.

$$Time(Rr) = min\left(\frac{1}{TT_{max} - TT}\right) \tag{22}$$

In tourism planning, it is crucial to understand the tourists' interest in the generated routes. To quantify this level of interest, a function was introduced to represent the tourists' interest in the generated route Rr. Formula (23) shows the calculation method of this function.

$$I(Rr) = \frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i} \tag{23}$$

When considering multi-objective constraint problems, the impact of time, cost, and attraction popularity on tourists' travel experience should be comprehensively considered. In order to evaluate the quality of the itinerary, a function such as formula (24) was introduced, and the result represents the tourist's itinerary experience.

$$Value(Rr) = A\cdot\frac{TC}{TC_{max}} + B\cdot\frac{TT}{TT_{max}} + C\cdot\frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i} \tag{24}$$

In formula (24), the specific setting of parameter values takes into account changing factors. For example, for some tourists traveling to rural areas, they usually travel to relax, but the playing time is usually limited during holidays and other limited time, so time is still very important. Therefore, the impact of time on the quality of travel can be emphasized. If tourists are sensitive to expenses, the impact of expenses on the quality of the itinerary can be highlighted to meet the needs and limitations of tourists as much as possible, thereby improving the quality of the itinerary. With the continuous development of science and technology, entertainment robots can not only assist users in route navigation planning and traffic planning, but also provide rich entertainment functions to enhance users' travel experience. Users can get interesting travel information and entertainment content by interacting with the entertainment robot. The entertainment robot can recommend suitable tourist attractions and activities based on the user's interests and preferences. By analyzing users' historical preferences and recommendation algorithms, entertainment robots can personalize travel routes for users and provide the best tour plan. This provides users with a more personalized travel experience, allowing them to better enjoy the fun of travel. Entertainment robots can also engage in human–machine conversations with users through speech recognition and natural language processing technology. Users can ask the robot questions, and the entertainment robot will quickly respond and provide detailed answers. This interactive way can not only provide users with the required travel information, but also bring fun and entertainment to users, increasing the fun and interest of travel.

4.2. Path planning and navigation function process

As shown in Fig. 4, in the functional process of itinerary planning, the system checks the date, departure, destination, travel days, budget, and other information entered by the user to ensure that they are legal, complete, and accurate. If the user enters incorrect or incomplete information, the system prompts the user to make modifications or improvements. Once the user's input information is confirmed by the system to be correct and valid, the system will obtain attraction information and traffic information from the database. This information includes the name, address, opening hours, ticket prices, etc. of the scenic spots, as well as the distance between the scenic spots, transportation mode, transportation time, transportation costs, etc. This information will help the system with itinerary planning. Next, the system will call the itinerary planning algorithm to generate the user's travel plan. The travel planning algorithm will generate the optimal travel plan based on factors such as user input information, scenic spot information, and transportation information, taking into account factors such as travel time, scenic spot travel time, transportation time, and expenses. In the process of generating travel plans, the system also considers the user's

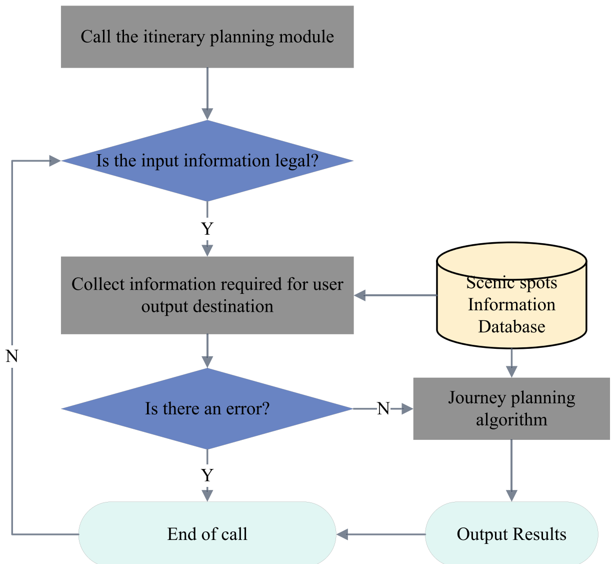

Fig. 4. Functional flowchart of the itinerary planning module.

travel preferences, such as whether they like different types of scenic spots such as cultural relics, natural scenery, shopping, etc. Finally, the system will output the itinerary planning results to the user. The itinerary planning results include detailed information such as travel date, departure place, destination, passing scenic spots, sightseeing time, transportation mode, transportation time, and expenses. Users can arrange their travel plans based on this information, and can also make appropriate modifications and adjustments to their itinerary according to their needs and preferences.

In the process of trip planning, the entertainment robot can also combine the user's entertainment preferences and preferences to provide personalized travel recommendations and entertainment content. By analyzing users' interests and recommendation algorithms, entertainment robots can recommend entertainment activities and attractions suitable for users according to their preferences. This allows users to get more entertainment experiences during travel and meet their expectations and entertainment needs for travel. For example, if the user likes history and culture, the entertainment robot can recommend visiting local historical sites and museums; If the user enjoys outdoor activities, the robot can provide recommended hiking routes and natural attractions. Entertainment robots can also provide entertainment content related to the destination, such as local music, dance, food and traditional festivals. By playing music, presenting dance performances or introducing the local food culture, entertainment robots can provide users with a richer and more diverse entertainment experience, help them gain an in-depth understanding of the local culture, and increase the fun and interest of travel. Entertainment robots can also add entertainment and interactivity to travel by interacting with users and providing some interesting mini-games and puzzles. These games and puzzles can help users relax on the road, have enjoyable interactions with entertainment robots, and learn more interesting facts and knowledge along the way.

4.3. Optimal navigation algorithm for travel time

In tourism, the size and pedestrian flow of scenic spots often affect the travel time of tourists at the scenic spots. When attractions are too crowded, tourists not only spend basic browsing time, but also spend extra time waiting in line or avoiding crowds, which can affect their travel experience and time planning.

In order to calculate the actual travel time of tourists at the scenic spot more accurately, the article introduces the congestion weight ui of the scenic spot and the actual travel time ti of tourists in the scenic spot i.

$$T_i = t_i + \mu_i t_i \tag{25}$$

$$\mu_i = aN_i \tag{26}$$

In formula (27), the correlation between the actual time a tourist passes through a certain path and several factors is considered. These factors include the basic time of the path, the degree of congestion of the path, the mode of transportation through the path, and the cost of passing through the path.

$$S_{ij} = t_{ij} + \lambda_{ij} t_{ij} \tag{27}$$

Formula (28) represents the path weight value λ The calculation method of ij. Path weight λ Ij is derived based on the actual situation, which reflects the impact of factors such as path congestion, transportation modes passing through the path, and cost expenditures on path selection.

$$\lambda_{ij} = \lambda_1 + \lambda_2 + \lambda_3 \tag{28}$$

Formula (29) represents the calculation method for path congestion degree Pij. The path congestion degree Pij is the ratio of real-time pedestrian traffic Nij to path capacity Mij obtained through RFID positioning technology.

$$P_{ij} = \frac{N_{ij}}{M_{ij}} \tag{29}$$

Calculate the congestion weight of the path through formulas (28) and (29) λij. This weight reflects the degree of congestion in the path, so that the impact of path selection on tourist travel time can be considered when planning a journey. By comprehensively considering the actual time, basic time, and congestion weight of the route, more suitable route choices are provided for tourists to improve journey quality and tourist satisfaction.

5. System application and testing

5.1. Simulation test of path planning effect

In the traditional A* algorithm, the heuristic rule is usually measured by the distance h(n) from a node to the target point. However, in the specific scenario of tourist attractions, distance is not the only heuristic rule, there are other factors to consider. For example, factors such as the flow of people, time cost and expense cost in tourist attractions will have an impact on route planning. The algorithm of personalized path planning in this paper focuses on modifying and improving the heuristic rules to make the obtained route more suitable for the specific scene of tourism.

The insertion time spent can be calculated by the formula (30):

$$Shift_k = T_k + Wait_k + t_{sk} \tag{30}$$

The waiting time is:

$$Wait_k = f(r_k) \tag{31}$$

After calculating the insertion time cost and waiting time, the maximum profit value of the insertion point can be calculated according to formula (32). The maximum return value of a node refers to the maximum expected return from that node to the endpoint.

$$Ratio_k = S_k / Shift_k \tag{32}$$

In path planning, determine whether the node corresponding to the maximum revenue value in the OPEN table meets the total time constraint condition, obtain the walking time required for the node to reach the endpoint, the time to reach the point, and the time spent playing at the point. According to formula (33), determine whether the node Vk meets the total time constraint condition:

$$r_k + Shift_k + timearc[k][n] < Totaltime \quad (33)$$

Table 1 provides some comparative parameters obtained by different algorithms for generating play routes, mainly including the final generated route, total play time spent, total travel distance, and final revenue value.

From Table 1, it can be seen that all three algorithms can find the walking path from the starting point to the target point, and heuristic functions can help the algorithm find the optimal solution more quickly. The personalized path planning algorithm has obvious advantages in terms of total play time, total travel distance, and final revenue value. This is because personalized path planning algorithms can recommend the most suitable travel routes based on user preferences and historical records, while also considering the revenue value of each scenic spot, thus obtaining better route planning results.

As shown in Fig. 5, the longitude and latitude coordinates of multiple scenic spots are placed in the algorithm, and multiple objective functions are optimized while considering various constraint conditions to obtain the optimal tourism path planning scheme.

Hybrid genetic algorithm is capable of searching both globally and locally to find the optimal solution. In this problem, multiple objective functions are optimized, such as minimizing total time, minimizing total cost, maximizing attraction ratings, etc. At the same time, various constraints are also considered, such as no more than a certain range of travel time, no more than a certain limit of total expenses, and no less than a certain amount of travel time for each attraction. Hybrid genetic algorithms can improve the search efficiency of the algorithm by combining genetic operators and local search operators. Through continuous iteration and optimization, the optimal tourism path planning scheme is obtained. The final results will be recommended to users to help them better plan their travel routes. In practical applications, algorithms can be further optimized and personalized recommended based on user preferences and historical records, thereby improving user satisfaction and experience.

5.2. Performance analysis of multi-objective point secure path planning

Using Euclidean distance as the distance weight between two target points, compare and analyze the performance of these algorithms in path planning results. Based on the generated sequence data, the total length of the path will be calculated, and the depth first traversal algorithm will be used to calculate the optimal result of multi-objective point path planning. The results are shown in Table 2.

Table 3 presents the results of multi-objective point safety path planning experiments in urban environments.

According to the data in Table 3, the algorithm presented in this paper has performed well in urban multi-objective point safety path planning experiments and has strong practical value.

5.3. Testing the accuracy of various system functions

The system adopts a combination of network positioning and GPS positioning, which can be used during the first positioning to meet the needs of positioning time. But the error of network positioning is greater than that of GPS positioning, because the principle of network positioning is to determine the position through signal interaction between mobile phones and base stations, and the distribution of base stations is uneven and affected by the environment, resulting in significant errors. As GPS satellites are connected, GPS positioning begins to take effect, and network positioning stops serving, thereby improving the accuracy of location positioning. Usually, the accuracy of GPS positioning can reach within 10 m, which is more accurate than network positioning.

System response time refers to the time required for the system to respond when a user selects a function. When designing various functions of this system, we took into account the user experience and adopted reasonable optimization design. The results are shown in Table 4.

The path navigation module can help users plan the best walking route and navigate. During the testing process, select and test whether each road section can broadcast road direction information, the distance to the next turning point, and the turning direction of the intersection. The test results show that the accuracy of road navigation is relatively high. Due to user positioning errors, the system did not locate the exact location when reaching a certain road section, resulting in navigation errors in the road section. However, this kind of error is difficult to avoid, so it was also taken into account when designing the system, and

Table 1
Comparison of the Effects of Various Algorithms.

Use algorithm	Dijkstra's algorithm	A* algorithm	Personalized routing algorithm
Play time	51.18	51.23	164.88
Total distance	558.70	555.90	1,863.66
Time utilization rate	28.96 %	28.75 %	93.17 %
Total income value	7.15	7.14	19.21

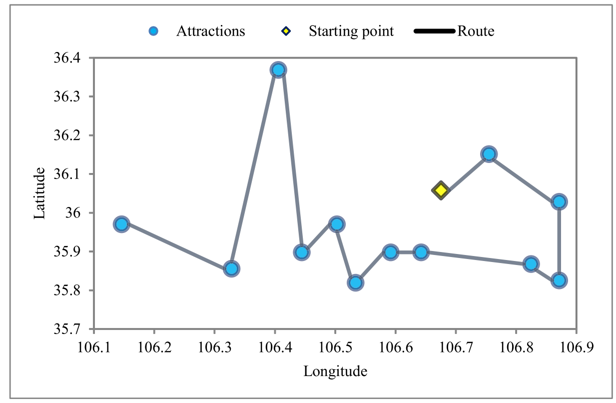

Fig. 5. Hybrid Genetic Algorithm Multi objective Constraint Solving Results.

Table 2
Comparison of the total length of paths in different multi-objective point path planning algorithms.

Number of target points K	GA	PtrNet	Textual algorithm
5	0.78	0.78	0.78
10	1.87	1.87	1.87
20	2.99	2.92	2.97

Table 3
Comparison of Safety Path Planning Results for Multiple Objective Points.

Number of target points K	GA	PtrNet	Textual algorithm
5	2056.77	2052.67	2052.67
10	3372.90	3066.50	2971.04
20	6623.97	6403.36	6394.12

Table 4
System Functional Tests.

Each function module	Correct rate (%)
Scenic spot statistics	100.00 %
Road section statistics	94.59 %
Optimization situation	99.77 %
Positioning situation	96.81 %

corresponding adjustments were made in route planning and navigation algorithms to reduce the impact of errors on navigation. In the testing of the scenic spot announcement and route correction modules, it was found that the test results of both modules were very good, fully meeting user needs. This also indicates that the system design process fully considers user needs and usage scenarios, thereby providing stable and accurate functionality.

Through the above tests, the system performs exceptionally well at various functional points, effectively helping users achieve functions such as travel guidance and path navigation. This indicates that the stability and reliability of the system have been fully considered in the system design and development process, and reasonable algorithms and technical means have been adopted to ensure the normal operation of the system. When designing the system, attention should be paid to user experience and ease of use. By optimizing interface design and interaction methods, users can quickly get started and use various functions of the system. We also provide detailed user manuals and operation guides, providing timely assistance and support for users when encountering problems during use. The self-service tourism service of the system can provide tourists with a convenient and fast travel experience. Through intelligent path planning and navigation functions, tourists can quickly and accurately find the attractions they want to visit, avoiding getting lost and wasting time. At the same time, the system also provides information such as scenic spot introductions, route recommendations, and real-time weather, providing comprehensive tourism services for tourists.

6. Conclusion

The intelligent personalized path planning function can provide users with more convenient and efficient travel services, meeting their constantly improving needs for travel. In order to achieve intelligent personalized path planning, this article designs an intelligent tourism path planning and navigation optimization system based on data mining and GIS technology. The system takes the shortest time as the optimization goal, and based on the real-time situation of the scenic area and the personal preferences of tourists, provides the best recommended tourist routes for the scenic area. The system analyzes and mines users' travel preferences through data mining algorithms, providing personalized travel services for users based on this. At the same time, the system also applies GIS technology to achieve precise positioning of the geographical location and distribution of scenic spots, as well as real-time monitoring and prediction of road conditions and weather, thus providing users with more accurate and comprehensive path planning and navigation services., The intelligent tourism path planning and navigation optimization system designed in this article has multiple advantages. The system can provide personalized travel services for users based on their personal preferences and real-time situation. The application of data mining and GIS technology can achieve precise positioning of the geographical location and distribution of scenic spots, as well as real-time monitoring and prediction of road conditions and weather, thus providing users with more accurate and comprehensive path planning and navigation services. The system can provide users with the best recommended tourist routes for scenic spots by minimizing time costs, improving their travel efficiency and satisfaction, and has a very practical and valuable application prospect. In the functional process of trip planning, the entertainment robot can combine the user's entertainment preferences and preferences to provide them with travel recommendations and entertainment content that are in line with their interests. This personalized service can help users get more entertainment experience during the travel process, meet their travel expectations and entertainment needs. Entertainment robots can also provide users with a richer and more diverse entertainment experience by providing entertainment content related to the destination, such as local music, dance, food and traditional festival activities. At the same time, through interaction with users, entertainment robots can provide some interesting small games and puzzles, adding entertainment and interactive travel. These entertainment activities and interactions can help users relax during the journey, have a pleasant interaction with the entertainment robot, and learn more interesting facts and knowledge in the process of entertainment. Therefore, the application of entertainment robots in tourism intelligent services can greatly improve the entertainment experience of users. With personalized travel recommendations, entertainment content related to the destination, and interesting interactive activities, entertainment robots enable users to have more fun and satisfaction during their travels. The application of such intelligent entertainment robots helps to enhance the competitiveness of the tourism industry and provide users with a better travel experience.

Funding

This study and all authors have received no funding.

CRediT authorship contribution statement

Ai Rong: Writing – original draft, Resources, Conceptualization. **Song Jianwei:** Writing – original draft, Project administration. **Xie Xiaowei:** Writing – review & editing, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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