The Investigation of Advancements in Intelligent Tourism Route Planning Based on Path Generation Algorithms

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Abstract: Due to individual differences in preferences and travel costs, it is challenging to provide accurate travel route planning to allow users to obtain personalized travel route recommendations. In this article, we analyze in detail the four commonly used path generation methods in the past, namely exact algorithm, heuristic algorithm, collaborative filtering algorithm and genetic algorithm, and analyze the ideas and specific implementation of these algorithms. We then discuss the practical application of tourism route planning, The A* algorithm and genetic algorithm, which are heuristic algorithms, are widely used in navigation application design, travel planning, and other path planning problems. The collaborative filtering algorithm is used to implement personalized route recommendations based on user preferences. Finally, we come to the conclusion, this study can sort out and integrate the research results in the field of tourism route planning, helping researchers understand the development status and trends of current research. With the development of technologies such as artificial intelligence and data mining, future travel route planning may become increasingly intelligent, capable of making personalized recommendations based on tourists' preferences, real-time traffic and other factors.

1 INTRODUCTION

Path planning refers to the process of determining, within a particular environment, the optimal route from a starting point to an end point (Damos, 2021). As the economic developing and living standard rising, traveling has become a significant kind of recreation. It's now crucial to design their own route for individuals in advance of travel in order to ensure a nice experience. The qualities of a self-driving tour are independence, adaptability, diversity, and selection. The self-driving tour's path planning, which can be time-consuming and expensive, greatly affects the entire experience. To enhance the self-driving trip experience and lower overall costs, we should investigate a self-driving travel path planning technique.

The predecessor of path planning problems is the Traveling Salesman Problem (TSP). Traditional methods for solving this kind of problem involve graph theory algorithms, such as using the Dijkstra algorithm to process weighted directed graphs to obtain the shortest path for the urban transportation (Sari, 2021). Another approach is heuristic algorithms , such as the ant colony algorithm and genetic algorithms. Adding more influencing factors to those traditional algorithms is the main way to improve model performance. For example, the Adaptive Ant Colony Algorithm (IAACO) introduces angle guidance factors into the ACO to effectively improve the real-time performance of the model (Miao, 2021). In the case of self-driving tour path planning, it is essential to handle larger scales and varieties of data and provide users with comfortable and personalized customized routes. However, traditional algorithms have difficulties in solving this issue.

Consequently, a lot of research has been done in the area of trip route planning in recent years using machine learning and deep learning models. Based on autoregressive time series models and deep learning

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models, the new model can dynamically adjust based on real-time traffic locations and interact with the environment to achieve real-time traffic data prediction, minimizing travel time (Geng, 2021). Using techniques for heterogeneous network embedding to handle multimodal input and extract valuable information. After then, by integrating supplementary data using attention-based deep learning to forecast the subsequent Points of Interest (POI), achieving a multi-task path planning model (Huang, 2023). Green Path incorporates environmental factors into the model consideration, introduces the environmental impedance model, offers walking and cycling as travel mode choices, and can optimize route planning results based on different environmental factors, achieving a multimodal route planning model (Helle, 2023). This article aims to summarize the research work on travel path planning problems, identify unresolved issues in this field, and provide personal insights for future work directions.

The paper is structured as follows. First, we introduce some the previous traditional path planning algorithms. Then, we discuss the improvements on the previous algorithm in detail, the feasibility and the specific implementation of tourism route planning, and finally summarize the entire article and draw the final conclusion.

2 METHODS

2.1 Exact Algorithm

Exact algorithms refer to algorithms that obtain the global optimal solution by calculating all possible solutions, including Branch and Bound, Cutting Plane, Branch and Cut Methods and etc. The Branch and Bound Method divides the problem into multiple subproblems, determines the upper and lower bounds of each subproblems, solves the local optimal solution, and then further branches to bound. Based on this method, Christofides et al. utilized the spanning, tree search method to accurately solve problems with up to 25 customer points (Christofides, 1981). The maximum clique problem proposed by Jiang et al. executes multiple subtasks in parallel and allows the subtasks to share the latest computed lower bounds, when a subtask's upper bound is smaller than the maximal clique's lower bound, the subtask is terminated to narrow the search scope, effectively improving the efficiency of the algorithm (Jiang, 2023).

2.2 Heuristic Algorithm

Heuristic algorithm is an effective method derived from biological activities in nature, for solving path planning problems. Line and Kernighan utilized this approach to deal with the classical Travelling Salesman Problem (Lin, 1973). Heuristic algorithm typically cannot guarantee to obtain the global optimal solution, they can find relatively good approximate solutions within a specified time frame, making them capable of handling large-scale NP hard problems. One of the most used heuristic algorithms is the Ant Colony Optimization Algorithm. The Ant Colony Optimization Algorithm is modeled after the foraging behaviors of real ants. Ants mark the most efficient paths for other members to follow by releasing pheromones (Dorigo, 2006). In order to increase the size of the solution space and decrease the impact of a small number of meeting ants on the results, Gao suggested merging searching ants and adding a threshold constant, effectively optimizing the slow convergence and low efficiency of the original ant colony algorithm (Gao, 2020). Li et al. merged the ant colony method with the greedy algorithm to create a novel ant colony optimization technique based on an adaptable greedy approach. Greedy algorithm chooses the local best solution at each stage. By modifying control parameters, the greedy algorithm is used to continuously change the ant colony's preference degree for route selection, accelerating the iteration process and hastening the discovery of the global optimal solution (Li, 2022).

2.3 Collaborative Filtering Algorithm

The idea behind collaborative filtering is to identify some similarities (either between users or similarity between objects) through the behavior of the group, and use these similarities to make decisions and recommendations for users. In order to achieve customized travel route planning, many studies have developed a system that combines big data, satellite positioning, crawler algorithms and other technologies. Cenamor studied and discussed travel routes based on positioning situations and developed Plantour (Cenamor, 2013), a system for generating routes and recommending tourist attractions. Based on user status, user-contributed material and other information from social media accounts, the Plantour system will collect and compile large amounts of data and determine which attractions the user likes and dislikes. Depending on the user's trip time and the most well-liked attractions on the Internet, to offer menu-based preset routes and attraction suggestions.

2.4 Genetic Algorithm

Simple Genetic Algorithm (SGA) generates an initial population through a random method. The poor individual fitness of the beginning population will limit the algorithm's pace of convergence to some degree. Yu studied the genetic algorithm in light of this (Yu, 2014). The heuristic crossover operator, which is based on the greedy approach, is utilized to maximize the crossover results. The greedy algorithm is used to start the population on the basis of the basic genetic algorithm. Studies and research demonstrate that when the population size is modest, the enhanced genetic algorithm may be applied to achieve more dependable optimization capabilities.

An enhanced single-parent genetic algorithm was suggested by Hu et al (Hu, 2019). This paper developed a novel coding technique that, during population initialization, may produce people with random distribution centers by drawing inspiration from the two-stage chromosomal coding method: utilizing an enhanced Lastly, a mixed selection operator is employed to retain and select the population, keeping the algorithm from prematurely convergent. The single-parent genetic operation is utilized to optimize the route. According to the study, the algorithm may be used to design trip routes and find the shortest path with high performance.

In order to address the traveling salesman issue, Chen et al. enhanced the evolutionary method using pointer networks (Chen, 2020), a neural network that, given a discrete input sequence, can ascertain the conditional probability of an output sequence. Low- and medium-level problems can be solved by it successfully. High accuracy predictions may be made on the solution to dimensional combination optimization issues. The pointer network's basic idea is to translate an input into a sequence of pointers that, in accordance with probability, refer to the input sequence elements. The improved genetic algorithm will generate a high-quality initial population through the pointer network. The initial population of the pointer network is then combined with the random initial population to determine the optimal individual. The retention strategy retains excellent individuals on both sides to form a new initial population. According to experimental findings, the enhanced algorithm's convergence speed and optimization capacity have greatly increased. As a consequence, it is possible to use genetic algorithms more successfully to the traveling salesman issue.

3 DISCUSSIONS

3.1 The Application of Path Planning Algorithms

The heuristic algorithms, collaborative filtering algorithms, and genetic algorithms mentioned above have demonstrated excellent performance in solving various practical path planning problems. Travel apps such as Ctrip, Gaode Maps, Uber, etc., have utilized these algorithms to provide users convenient and efficient services for everyday needs and travel planning.

The A* algorithm, a heuristic algorithm widely used in path planning, exhibits significant advantages in practical scenarios due to its efficiency, completeness, and robust adaptability. Navigation systems, autonomous vehicle driving, and robot path planning widely employ the A* algorithm. From our perspective, the popularity of the A* algorithm stems primarily from its ability to efficiently find the optimal path while maintaining strong real-time performance and adaptability. During the search process, the A* algorithm utilizes heuristic information to effectively reduce the search space, thereby improving search efficiency. For instance, Gaode Maps employs the A* algorithm combined with straight-line distance estimation and cost function design, comprehensively considering factors such as road length, traffic conditions, and congestion, to give consumers the best possible mix of path planning from the starting point to the destination as fast as feasible, and can provide users with better solutions based on real-time conditions.

The genetic algorithm, which has strong global search capabilities, is suitable for solving multimodal optimization problems. In our view, the advantages of genetic algorithms lie in their parallelism, ability to handle high-dimensional, nonlinear, and non-differentiable optimization problems, and strong adaptability. They can also perform parallel computations in distributed environments, exhibiting good scalability and generalization ability to better handle practical path planning problems with massive data. Shivgan effectively solved the drone path planning problem using genetic algorithms (Shivgan, 2020). Compared to greedy algorithms, genetic algorithms are less likely to fall into local optima, significantly reducing energy consumption and improving the performance and efficiency of drone operations.

Collaborative filtering algorithms enable path planning models to better address user preference issues and achieve personalized recommendations.

These algorithms utilize large amounts of user data and form information to discover user preferences and historical behavior, thereby customizing the optimal travel itinerary tailored to users' habits and preferences. For example, the Plantour system is designed based on collaborative filtering algorithms. While generating routes, it provides personalized recommendation services to users based on the analysis of a large amount of data (Cenamor, 2013).

3.2 Disadvantages and Challenges

Although the aforementioned three algorithms have achieved remarkable success in practical applications, each method still exhibits inevitable limitations. Firstly, the A* algorithm heavily relies on heuristic information to guide the search process. The heuristic function chosen has a major influence on how accurate the model's output is. However, in complex and dynamic environments, heuristic information is often incomplete or inaccurate, which may hinder the A* algorithm from finding the globally optimal solution. Secondly, data, as a valuable resource in today's society, is not always available. This limits the effectiveness of models such as collaborative filtering algorithms, which rely on capturing data features from large amounts of information, leading to inaccurate recommendations. Lastly, genetic algorithms, with good scalability and adaptability, typically require extensive iterations and adjustments to find the optimal solution for multimodal optimization problems in the search space, significantly increasing computational costs.

3.3 Future Prospects

In light of the aforementioned issues, several potential solutions could be determined. Firstly, one could adopt a hybrid approach that combines multiple algorithms to mitigate the shortcomings of individual methods and amplify their strengths. For example, integrating the A* algorithm with reinforcement learning techniques could be advantageous. By leveraging reinforcement learning's ability to autonomously learn from interactions with the environment, it reduces reliance on heuristic functions, adapts better to dynamic changes, and enhances the robustness and stability of path planning. Secondly, incorporating meta-learning can reduce the model's dependence on data, enabling it to quickly infer the optimal learning strategy for new tasks with limited data. Lastly, by utilizing parallelization techniques or computational platforms such as Apache Spark, one can accelerate the search process, reduce iteration counts, simplify genetic algorithms, enhance algorithm efficiency, and arrive at a more affordable ideal option.

4 CONCLUSIONS

In this work, we offer a summary associated with tourist route planning and its four commonly used algorithms. This paper also discusses the practical application of tourism route planning with a large number of examples. Analyzing the limitations of the above four algorithms in solving real-world problems today, and proposed personal insights on how to further optimize and improve existing models by integrating cutting-edge technologies such as deep learning and machine learning. This study systematically summarizes the current research progress in terms of designing tourist routes, including development of different methods, algorithms and application scenarios, which can help researchers understand the latest developments in this field. This study also conducts an in-depth analysis of the existing problems and limitations of current research, proposes the focus and direction of future research, and provides guidance and inspiration for researchers. Future travel route planning will increasingly incorporate big data and artificial intelligence technology to achieve in-depth exploration of tourist behaviors and preferences, providing better support for personalized travel route planning.

AUTHORS CONTRIBUTION

All the authors contributed equally, and their names were listed in alphabetical order.

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