Drone Dynamic Planning Nature Reserve Policy Based on Path Planning and Fuzzy Comprehensive Evaluation

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Abstract. As a famous wildlife sanctuary and national park in Africa, Kenya's Maasai Mara is also suffering from the scourge brought about by the contradiction between human and nature. For the conservation of local wildlife and other natural resources, this paper curb poaching and other violations by assigning patrolling tasks to drones**.** Good improvements are made to the genetic algorithm in the article. To address balancing the interests of people living in the area and analyze human-animal interactions, A-star algorithm for drone path planning came out. Experimented by setting the barrier grid and target grid for the area after rasterization，it got excellent results. In order to rank and compare program results and forecast our models, the fuzzy integrated evaluation algorithm is selected for assessment and the Markov model is compatible with prediction. The model discusses some special cases and applications of the model in other regions. Therefore, our method is also more applicable to other similar wildlife sanctuaries.

Keywords: Drone; A-star; Fuzzy Comprehensive Evaluation; Rasterization Markov

1 Introduction

Maasai Mara is one of the most famous and important wildlife conservation and wilderness areas in Africa, world-renowned for its exceptional populations of lion, leopard, cheetah and African bush elephant. It also hosts as one of the ten Wonders of the World. It is undeniable that Maasai Mara has very precious biological resources, especially a very large number of large herbivores, which also attracts tourists from all over the world to visit here. The local government has also increased its support for tourism, but economic development has also brought damage to the natural environment and natural resources. In order to further balance the relationship between local ecology and economy, it is imminent to formulate and implement a series of new policies and measures. In response to the development of policies and strategies for Maasai Mara, the following three questions are posed in the article: 1. Conserve local wildlife and other natural resources. 2. Balance the interests

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of people living in the area and analyze human-animal interactions. 3.Rank and compare program results and forecast models.

The current state of research in response to these three questions is as follows: 1. More drone's tasks can be performed in the given mission time by efficient incorporation of communication in the path design. [1] 2.Comparison of parallel genetic algorithm and particle swarm optimization for real-time UAV path planning.[2] 3.UAV path planning using artificial potential field method updated by optimal control theory.[3] 4.Development and evaluation of drone mounted sprayer for pesticide applications to crops.[4]

To address these tasks, two distinct optimized models have been constructed. The mode I: Path Planning Model Based on A-star Algorithm sums the minimum cost function and the heuristic function to form the solution model. This model balances the interests of people living in the area and is used to analyze human-animal interactions Experimented by setting the barrier grid and target grid for the area after rasterization, this model gives excellent results. The model II: Evaluation and Prediction of Measures Based on Fuzzy Comprehensive Evaluation Model and Markov Prediction Model ranks and compares program results and forecasts our models above. In the remainder of the paper, detailed descriptions of theme thodologies used and the construction of the two models are initially provided, with Section 2 delving into the intrinsic representations of these models for this specific task. Subsequently, in Section 3, a series of experiments offer compelling evidence to endorse the efficacy of the proposed algorithms.

2 Model

In this section, this paper provides a general introduction to Path Planning Model Based on A-star Algorithm, as well as Evaluation and Prediction of Measures Based on Fuzzy Comprehensive Evaluation Model and Markov Prediction Model.

2.1 Path Planning Model Based on A-star Algorithm

In order to better deal with the problems raised by the articles, spatial model should be first determined. [5] So this paper rasterizes the area, and the results of the rasterization are placed in the chapter on experimental results and analysis. The A-star algorithm is a heuristic path search algorithm [6]. The A-star algorithm is essentially a combination of Dijkstra's algorithm and the optimal search algorithm [7] which is no need to traverse the whole tree.

During the iterative process of the algorithm, the direction of its node extension is determined according to the cost of the current path and the cost of extending the path to the target node. Specifically, the cost function of the A-star algorithm is:

$$f(n) = g(n) + h(n) \tag{1}$$

Among them, node n is the next node on the current path, g(n) represents the actual minimum cost of the path from the starting node to node n, and h(n) is a heuristic function used to estimate the cost of the path from node n to the target node. Minimum cost required. In general, for the estimation function h(n), as long as the estimated value is not higher than the actual cost, the A-star algorithm will guarantee to return the shortest path from the starting node to the target node. In a grid map, the heuristic function h(n) is generally represented by the Manhattan distance between two points, and its specific expression formula is as follows:

$$h(n) = \left|X_g - X_n\right| + \left|Y_g - Y_n\right| \tag{2}$$

Among them, (Xg, Yg) represents the coordinates of the target node, (Xn, Yn) represents the coordinates of node n.

The A-star algorithm is a pathfinding algorithm that aims to find the shortest path between two points on a graph or grid. It achieves this by iteratively selecting nodes with minimal estimated costs from an OpenList set, usually managed through a priority queue data structure. During each iteration, it removes and explores nodes based on their cost function value f(n), which represents both their heuristic estimate and actual distance traveled so far (g(n)). Additionally, it updates these values for neighboring nodes as they are explored until reaching a target node whose f(n) value becomes lower than any other remaining node in the queue.

2.2 Evaluation and prediction based on fuzzy sets and Markov Model

In this section, this paper will utilize the fuzzy comprehensive evaluation model to conduct a thorough analysis and evaluation of the applicability of the A-star algorithm in three distinct areas: the eastern sector, central sector, and mara triangle. By employing this model, we aim to provide a comprehensive understanding of how effectively the A-star algorithm can be implemented in each specific region. Furthermore, after analyzing and evaluating the data using the fuzzy comprehensive evaluation model, we will proceed with utilizing the Markov prediction model. This predictive approach allows us to make informed projections based on historical patterns and trends observed within our dataset.[8]

Define the state transition probability [9]: According to the definition of conditional probability, the state transition probability P(Ei→Ej) from state Ei to state Ej is the conditional probability P(Ej/Ei).

$$P\left(E_i \to E_j\right) = P\left(E_j/E_i\right) = P_{ij} \tag{3}$$

Assume that a certain predicted event has E1, E2, ..., En, a total of n possible states. Denote Pij as the state transition probability from state Ei to state Ej, then the state transition probability matrix can be made.

$$\begin{cases} 0 \leqslant P_{ij} \leqslant 1 & (i,j = 1,2,\cdots,n) \\ \sum_{j=1}^{n} P_{ij} = 1 & (i = 1,2,\cdots,n) \end{cases} \tag{4}$$

Another term needs to be introduced: state probability πj(k). πj(k) represents the probability that the event is in the state Ej at the k-th moment (period) under the condition that the state of the event is known at the initial (k=0), after k times of state transitions.

If the travel vector π(k)=[π1(b), π2(b),... ,πn(k)], then the recursive formula for successively calculating the state probability can be obtained:

$$\begin{cases} \pi(1) = \pi(0)P \\ \pi(2) = \pi(1)P = \pi(0)P^2 \\ \vdots \\ \pi(k) = \pi(k-1)P = \pi(0)P^k \end{cases} \tag{5}$$

The state probability obtained after an infinite number of state transitions is called the ultimate state probability, or the equilibrium state probability.

$$\pi_i = \lim_{k\to\infty} \pi_i(k)(i = 1,2,\cdots,n) \tag{6}$$

3 Results

The red squares represent obstacles (including crown trees, wild animals, wild animal territories, etc.), and the blue squares represent destinations (including sightseeing spots, drone charging stations, etc.). In order to prove the practicability of the A-star algorithm, this paper use the A-star algorithm to calculate the grid map with obstacles and tasks randomly set before, and finally get the shortest path, as shown in the figure 1:

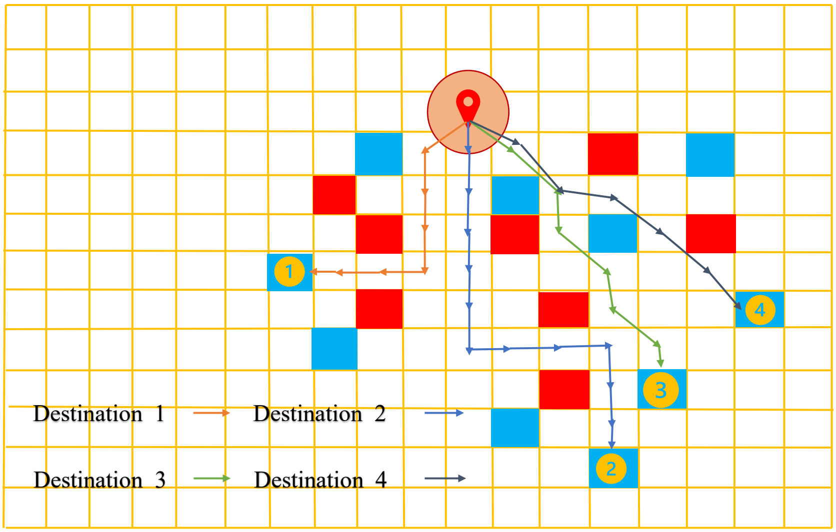

Fig. 1. Path map of A-star algorithm planning

As can be seen from the figure above, the effect of the A-star algorithm is better. It can be used in practical problems to effectively protect wild animals, ensure the safety of tourists, realize aerial viewing of parks and realize the interaction between humans and animals, etc.

A review [10] of the relevant literature resulted in the following estimates that the use of drones will reduce the number of wild animals hunted in protected areas by 30% and increase local economic income by 10%. Bringing this valuation into the model yields the predictions.We substitute this estimated value into the data of previous years, and then divide the number of hunts in previous years into three levels of low, medium and high, and divide the economic income into three levels of low, medium and high, and then perform Markov prediction to obtain the final prediction results.

The data in Figure 2 show that our measures are very effective in protecting the ecology and increasing income.

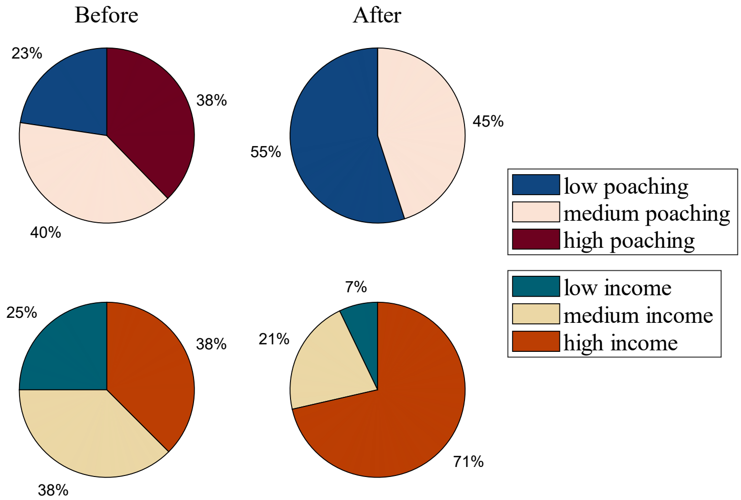

Fig. 2. Comparison chart of forecast results

4 Conclusion

Four methods are used to improve the traditional genetic algorithm and improve the performance of the algorithm, including population classification strategy, excellent individual genetic strategy, adaptive crossover and mutation operator, and simulated annealing Metropolis criterion.A-star algorithm is adopted in the region, which is the most effective direct search method for solving the shortest path in the static road network and can better deal with the problem of tour route planning in the protected area.Sub-regions are divided, and then tested the applicability of different measures in different regions through the fuzzy comprehensive evaluation model, which enhanced the practicability and authority of the model.

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