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Analysis of Ignition Points Based on Annealing Algorithm

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Abstract: *We summarize the distribution range of large-scale fires in Victoria over the years, and predict and explain that this model has good adaptability to the changes of fires. This paper proposes a model that predicts the cost of drones, based on screening all possible ignition points. In order to ensure economy and security, we use cluster analysis to divide the selected ignition points into 9 categories, introduce 0-1 variables, use model annealing algorithm to find the shortest path, iterative search, and obtain the global optimal solution of the optimization problem. We need to send a total SSA 162 UAVs, and SSA UAV equipment increased by 141, equipment costs increased by $1410000.*

Keywords: *ignition point, UAV, annealing algorithm, annealing algorithm*

1. Introduction

Australia's 2019-2020 fire season has caused devastating wildfires in every state, with the greatest impact on New South Wales and eastern Victoria. Wildfires occur in severe droughts and persistent heat waves, exacerbated by climate change.

Firstly, the distribution range of large fire in Victoria is summarized, and the model has good adaptability to the change of fire in the next ten years. Secondly, according to the forecast of UAV cost, according to the collected data, because the ignition point has great repeatability, we screen all possible ignition points and select 69 suitable points to deal with. Under the guarantee of economy and security, the selected ignition points are divided into 9 categories by cluster analysis. Finally, we introduce 0-1 variables l_{ij}, use model annealing algorithm to find the shortest path, iterative search, and obtain the global optimal solution of the optimization problem.

2. Establishment of Model

First of all, the adaptability of the model is explained as follows: from the previous Victorian fires, most of the fires occurred in rural mountainous areas, while all major fires occurred in Dafangshui Ridge. Therefore, this model is mainly established for mountain areas and urban monitoring.

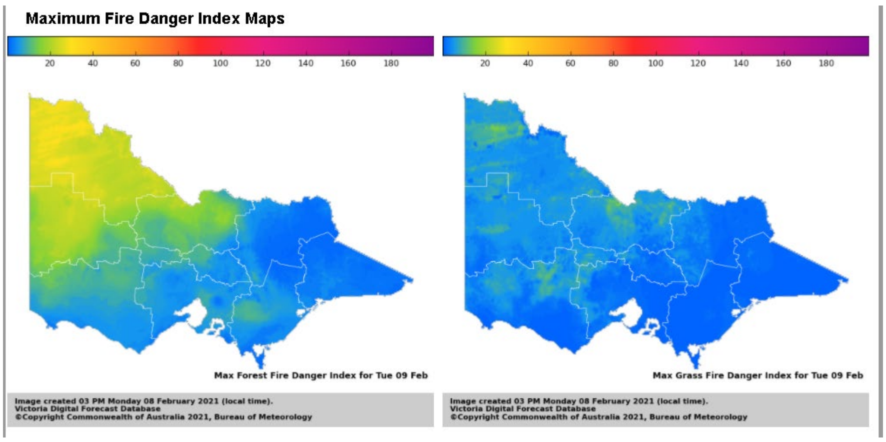

Figure 1: Maximum Fire Hazard Index [1]

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At the same time, according to the maximum fire risk index map, the high risk areas for key monitoring.

It requires us to consider what measures can be taken to deal with the possibility of future fires. We take into account the danger of the fire point, we should focus on the SSA UAV inspection to detect the fire point environment, if there are abnormal circumstances, should report to the CFA for action.

Because the ignition point has great repeatability, we screen all possible ignition points and select 69 suitable points to deal with. And reasonable consideration of economy and safety, so as to send SSA UAV detection and inspection.

According to the topic and hypothesis, the maximum flight distance of UAV is 30 km. Therefore, we need to consider the allocation of SSA UAV to ensure economy and safety. The following figure shows the longitude and latitude distribution of the ignition point.

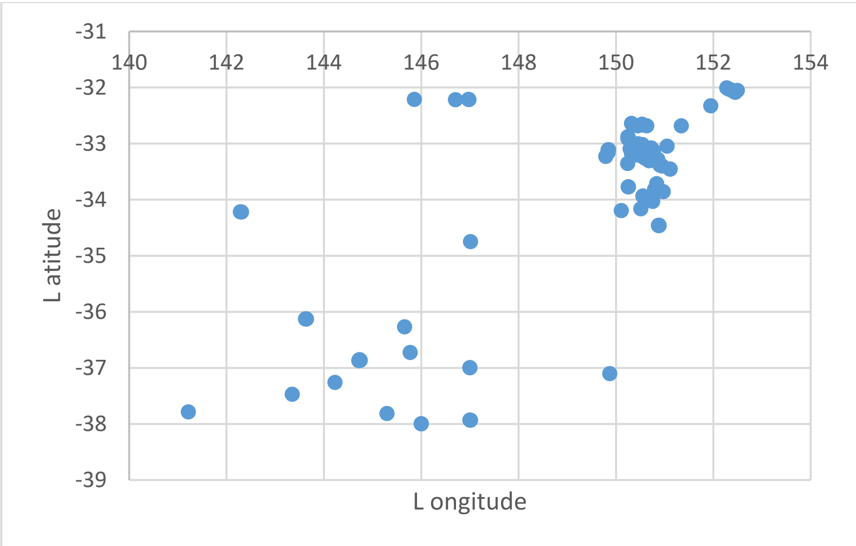

Figure 2: Latitude and longitude distribution of ignition points [2]

For the convenience of follow-up research, we propose two concepts ——" discrete "and" basic piece ". A point "discrete" means that there is no other point distribution in a relatively large neighborhood of the point, such as a circle neighborhood with the point as the center and the radius of 5 km. The so-called "basic piece" refers to the latitude and longitude map refers to a small area, dense distribution of a large number of points.

Because the distribution of different ignition points is different, we consider using K-Means clustering algorithm to classify ignition points. The purpose of clustering analysis is to divide the classification objects into several classes according to certain rules, which are not given in advance, but determined according to the characteristics of the data. These objects in the same class tend to be similar to each other in a sense. [3] K-Means algorithm is a non-hierarchical clustering algorithm based on distance. On the basis of minimizing error function, the data is divided into K classes planned in advance, and distance is used as the evaluation index of its similarity, that is, the closer the distance between the two objects is. The greater the similarity.

Basic steps of K-Means algorithm:

(1) Select K object from the data as the initial cluster center

(2) Calculate the distance from each cluster object to the cluster center;

(3) Recalculate each cluster center

(4) Calculate the standard measure function until the maximum number of iterations is reached and stop. Otherwise continue.

We use cluster analysis to divide the selected ignition points into 9 categories. Among them, 6 classes are composed of only one discrete point, 3 of which are composed of 3,12 and 48 points, which belong to the "basic piece" region. For the discrete six points, i=1, 2,...,6, we each have a UAV for detection. S_iFor a "basic piece" area, we consider multiple SSA drones starting at the

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same time, so that each point takes the shortest route when it passes only once, and the smaller the total flight path of the UAV, It represents the highest efficiency of UAV mission, thus meeting the minimum number of UAVs sent out [4].

According to the relevant knowledge of geography, at the same longitude line, the difference of field distance is 111 km for each difference of 1 latitude, and at the same latitude line, the difference of 1 longitude and the actual distance is 1 km. $111\cos\theta$ θ This is 36 degrees.

At this point, the path selection problem, that is, whether the UAV SSA can go through the route between two points S_i S_j, we introduce 0-1 variable l_{ij}:

$$l_{ij} = \begin{cases} 0, \ have\ S_i \text{ to } S_j \\ 1, \ not\ have\ S_i \text{ to } S_j \end{cases}. \tag{1}$$

And our goal is to solve:

$$\min \sum_{0 \le i < j \le 29} d_{ij} l_{ij}. \tag{2}$$

For each ignition point S_i, SSA drone passes only once, so:

(1) When considering the starting point S_i of a path, the following relation is established:

$$\sum_{i \ne j} l_{ij} = 1. \tag{3}$$

(2) When the termination point of a path is assumed, the following relation is established:

$$\sum_{i \ne j} l_{ji} = 1. \tag{4}$$

In the above problem, the unknown quantity is 0-1 variable for the defined Euclidean distance. Combined with the above formula, the following 0-1 programming model can be established: [3]

$$\sum_{i \ne j} l_{ji} = 1. \tag{4}$$

$$min \sum_{0 \le i < j \le 29} d_{ij} l_{ij}$$

$$\text{s.t.} \begin{cases} \sum_{i \ne j} l_{ij} = 1 \\ \sum_{i \ne j} l_{ij} = 1 \\ l_{ij} = 0,1 \end{cases}$$

3. Analysis and solution of Model

Next, we use the model annealing algorithm to find the shortest path. The basic idea of simulated annealing algorithm is to compare a combinatorial optimization problem into a thermodynamic system and to compare the objective function$f(i)$ of the optimization problem into the energy of the system $E(i)$. The optimization solution process is compared to the annealing process in which the system gradually cools down (iterative search) to the lowest energy state.

The core idea is to accept a worse solution than the current solution with a certain probability, and then continue the search with this worse solution. In the search process, we give different weights to the three neighborhood structures, namely exchange structure, reverse structure and insert structure, and then choose which neighborhood structure to use by roulette.

According to the requirements of the question, the maximum flight distance of the UAV is 30km, the maximum speed is 20m /s, and the longest flight time is 2.50 hours.So a drone flying longest distance

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within the effective time of flight of 18 km. We set each drone work area is 30 km, unmanned aerial vehicle (uav) can no longer continue to detect after it reached the maximum flight time, so we consider every 30 km on the drone 2, to ensure that when unable to detect a drone, another drone can work normally, can detect makes within 30 km.Let's talk about the shortest path for multiple drones to traversing all the fires in three areas.

Next, we discuss three areas:

(1) Latitude range (-34.752,-32.008) longitude range (149.791,152.496)

The distribution of points in this area is dense, and the result is:

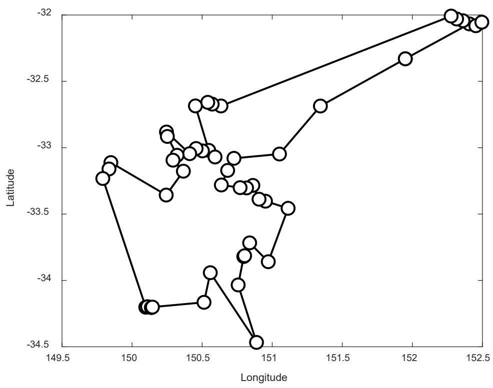

Figure 3: Results of Point Operation in Area

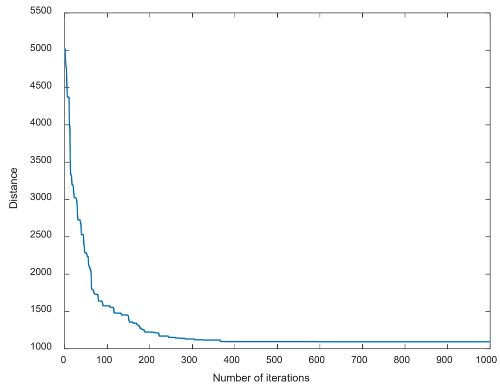

Figure 4: Total optimized route distance

At this time, the total distance of the global optimal route is 1093.2445km.The two drones have a range of 30 kilometers, so we need to send 37*2=74 drones.

(2) Latitude range (-32.216,-32.222) longitude range (146.705,146.982)

The results are:

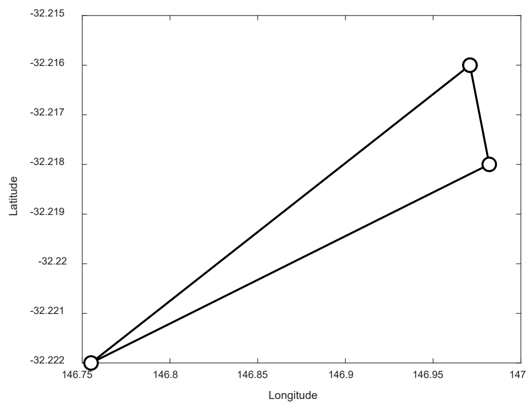

Figure 5: Distribution of longitude and latitude data

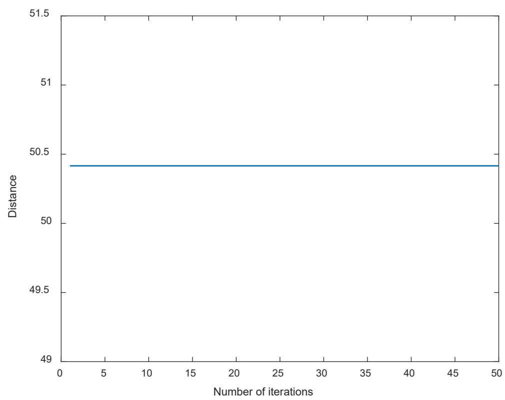

Figure 6: Total optimized route distance

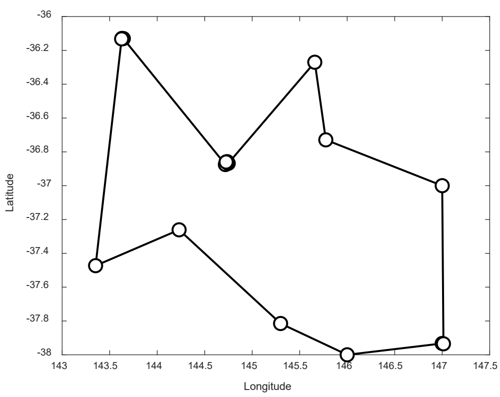

Figure 7: Distribution of longitude and latitude data

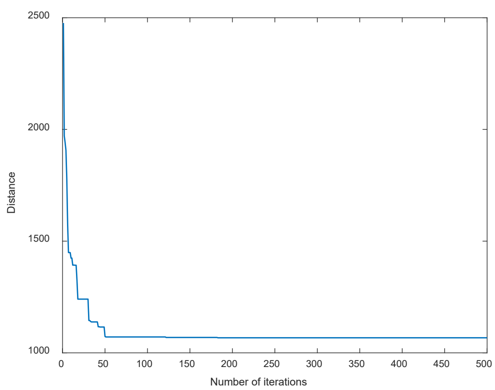

Figure 8: Total optimized route distance

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The total distance of the global optimal route is 50.19 km, and the working detection range of the two UAVs is 30 km, so we need to send four SSA UAVs.

(3) The latitude range is (-36.129,-38) the longitude range is (143.352,147), this part of the regional point is slightly dispersed, the result is:

At this time, the total distance of the global optimal route is 1067.4188km, and the working detection range of the two UAVs is 30 km, so we need to send 36*2=72 SSA UAVs.

To sum up, we need to send a total of 162 SSA UAVs, and the cost of the equipment is 162* 10,000 = $1620,000.Compared with the first question SSA UAV, the equipment increased by 141 aircraft, and the equipment cost increased by $1410,000.

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