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Research on Distribution of Radio Relay UAVs

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Abstract: *This paper determines the location of Radio Relay UAVs by considering three situations. We find the latitude and longitude distance can be used for all points are "discrete points". If all points are "basic pieces", this paper uses a geometric drawing board to illustrate the "gridded processing" process, and determine the location of the high generation repeater by calculating points, mark points and grid. For both "discrete" points and "basic pieces" points, they are operated as (1) and (2) respectively base on classifing them. All primary repeaters and discrete points not connected to any relay station are obtained. Finally, iterates repeatedly until the geographical distribution of all relay stations.*

Keywords: *distribution, discrete, basic pieces, repeater*

1. Introduction

We consider three situations in this paper:

All points are "discrete points" model:

By using the plane geometry principle of "the center line of a triangle must be less than the sum of the two sides of the triangle with its unified vertex ", if the distance between two discrete points is less than 40 km, a" primary repeater "is placed between them ". Then according to the distance between the "primary repeater" and the discrete points of the "primary repeater ", the iterative operation is continued. Until the distance between all repeaters and SOA is less than 20 km, the corresponding geographical distribution is determined.

All point "basic piece" models:

First, we regard this relatively dense small area as a rectangle and "gridding" the rectangular area according to 20 km. Then we calculate the relevant data to determine the number of points, mark points, grid, determine the location of the first generation repeater, and finally determine the location of the high generation repeater.

A model that contains both "discrete" points and "basic pieces" points:

The "discrete" points are classified with the "basic piece" points, and then the "discrete" points and the "basic piece" points are operated as (1) and (2) respectively. All primary repeaters and discrete points not connected to any relay station are obtained. Then iterates repeatedly until the geographical distribution of all relay stations, that is, the geographical distribution of radio relay UAVs.

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 and Solution of Model

In order to make the model simple, we declare the following three concepts:

1) Repeater, data points between each other and between the two "adjacent ":

A. Adjoining between repeaters: one repeater is set up on the other;

B. The repeater is adjacent to the ignition point: the repeater is set on the basis of the ignition point;

C. Adjoining between ignition points: the distance between the two is not more than 5 km;

2) Primary repeaters: repeaters based on the ignition point we selected;

3) High-generation repeaters: repeaters based on primary repeaters and some not adjacent to primary repeaters.

2.1 All points are "discrete points" model

Suppose there are N discrete points distributed in a region, respectively, and the distance between S_i and S_j is according to the analysis, that is:

$$d(P,Q) = \left[(111\cos 35°)\left|\xi_P - \xi_Q\right|^2 + 111\left|\eta_P - \eta_Q\right|^2\right]^{\frac{1}{2}}. \tag{1}$$

Where, $P(\xi_P, \eta_P)$ express the longitude and latitude of the point P, and $Q(\xi_Q, \eta_Q)$ express the longitude and latitude of the point Q.

When the BC midpoint is D, for any triangle, it is easy to know by the knowledge of trigonometry, and the length of AD must be strictly less than the sum of AB length and AC length. So, we think as follows:

If so $d(S_i, S_j) \leq 40km$, consider establishing a relay station at the midpoint of the station S_i and S_i, that is, the first relay station; otherwise, it will not be processed. For all the primary repeater stations and discrete points that are not connected to any repeater stations, N^1 is the number of these points, reset the coordinates of these points to be $S_i^1 (i = 1,2, \dots, N^1)$, and repeat the above operation.

If a relay station reaches a EOC distance of 20 km, the subsequent operation no longer puts the relay station in it. Until all new relay stations arrive EOC 20 km, stop operation. The result is the geographical distribution of relay station, that is, the geographical distribution of radio relay UAV.

2.2 A "basic piece" model for all points

In the actual situation of mountain fire, the occurrence of fire is extremely normal. The above situation is too extreme, not in line with the general situation, then consider a "basic piece" situation. Let's assume that the longitude interval of these densely distributed points is $[E_1, E_2]$, the latitude interval is $[P_1, P_2]$, because the latitude range changes are not particularly large, so when we involve data that require known latitudes, we process it by defining $P = \frac{1}{2}(P_1 + P_2)$ as latitude data.

We regard this relatively dense small area as a rectangle. Because the signal receiving range of the repeater is 20 km, we carry on the "grid processing" to the rectangular area according to 20 km ". A rectangle is drawn in a geometric drawing board and recorded as a rectangle ABCD, Take the existing rectangle as an example to illustrate the process of "gridding ":

①Calculating relevant data:

Longitude span: $F = |E_1 - E_2|$, latitude span: $Q = |P_1 - P_2|$.

The length of the rectangle is: $AD = BC = F \cdot \cos P \cdot 111, AB = DC = Q \cdot 111$.

②Determine the number of points:

Number of points AD and BC: $n_1 = \begin{cases} \left[\frac{AD}{20}\right], \text{ if } AD \equiv 0 \; mod \; 20 \\ \left[\frac{AD}{20}\right] + 1, \text{ else} \end{cases}$

Number of points AB and DC: $n_2 = \begin{cases} \left[\frac{AB}{20}\right], \text{ if } AB \equiv 0 \; mod \; 20 \\ \left[\frac{AB}{20}\right] + 1, \text{ else} \end{cases}$

③Marking points:

Divide the edge n_1 of AD into equal parts, $A = X_0, X_1, X_2, \dots, X_{n_1-1}, X_{n_1} = D$ from left and right. Among them, the latitude and longitude coordinates of each point $X_i(i = 0,1,2,\cdots,n_1 - 2, n_1 - 1, n_1)$ are $\left(P_2, E_1 + i \cdot \frac{AD}{n_1}\right)$.

Divide the edge n_2 of AB into equal parts, $A = Y_0, Y_1, Y_2, \dots, Y_{n_2-1}, Y_{n_2} = B$ from left and right. Among them, the latitude and longitude coordinates of each point $Y_j(j = 0,1,2,\cdots,n_2 - 2, n_2 - 1, n_2)$ are $\left(P_1 - i \cdot \frac{AD}{n_2}, E_1\right)$.

Similarly, bisect the BC edge n_1 and DC edge n_2 equally, and set the bisect points to $B = \tilde{X}_0, \tilde{X}_1, \tilde{X}_2, \cdots \tilde{X}_{n_1-2}, \tilde{X}_{n_1-1}, \tilde{X}_{n_1} = C$, $D = \tilde{Y}_0, \tilde{Y}_1, \tilde{Y}_2, \cdots \tilde{Y}_{n_1-2}, \tilde{Y}_{n_2-1}, \tilde{Y}_{n_2} = C$.

④Gridding:

For arbitrary $i = 0,1,2,\cdots,n_1 - 2, n_1 - 1, n_1$, for arbitrary, will be connected $j = 0,1,2,\cdots,n_2 - 2, n_2 - 1, n_2$, X_i will be connected with $\tilde{X}_i$, Y_i will be connected with $\tilde{Y}_i$, so get a grid.

⑤Location of primary repeaters:

AD edge, respectively $X_1, X_3, \dots, X_{l_1}$, as the location of the repeater

$$l_1 = \begin{cases} n_1, \text{ if } n_1 \equiv 0 \; mod \; 2 \\ n_1 - 1, \text{ if } n_1 \equiv 1 \; mod \; 2 \end{cases} \quad (2)$$

AB edge, respectively $Y_1, Y_3, \dots, Y_{l_1}$, as the location of the repeater

$$l_2 = \begin{cases} n_2, \text{ if } n_2 \equiv 0 \; mod \; 2 \\ n_2 - 1, \text{ if } n_2 \equiv 1 \; mod \; 2 \end{cases} \quad (3)$$

Along the parallel meridian and weft line, one point is separated, and one point is determined as the position of the primary repeater.

⑥Location of high-generation repeaters:

If a relay station reaches a EOC distance of 20 km, the subsequent operation no longer puts the relay station in it. Until all new relay stations arrive EOC 20 km, stop operation. The result is the geographical distribution of relay station, that is, the geographical distribution of radio relay UAV.

2.3 A model that contains both "discrete" points and "basic pieces" of points:

The "discrete" points are classified with the "basic piece" points, and then the "discrete" points and the "basic piece" points are operated as (1) and (2) respectively. All primary repeaters and discrete points not connected to any relay station are obtained. Then iterates repeatedly until the geographical distribution of all relay stations, that is, the geographical distribution of radio relay UAVs.

3. Evaluation and Promotion

3.1 Analysis of sensitivity

For the three groups of data we selected, the description quantity of fire frequency and fire degree Brigtness fluctuated continuously up and down by 5% and 10%. Since the number of SSA UAV is not sensitive to the frequency and degree of fire, we only considered the influence of the change of two parameters on the number of radio relay UAV. The sensitivity analysis of the model with three points

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changed is shown as follows:

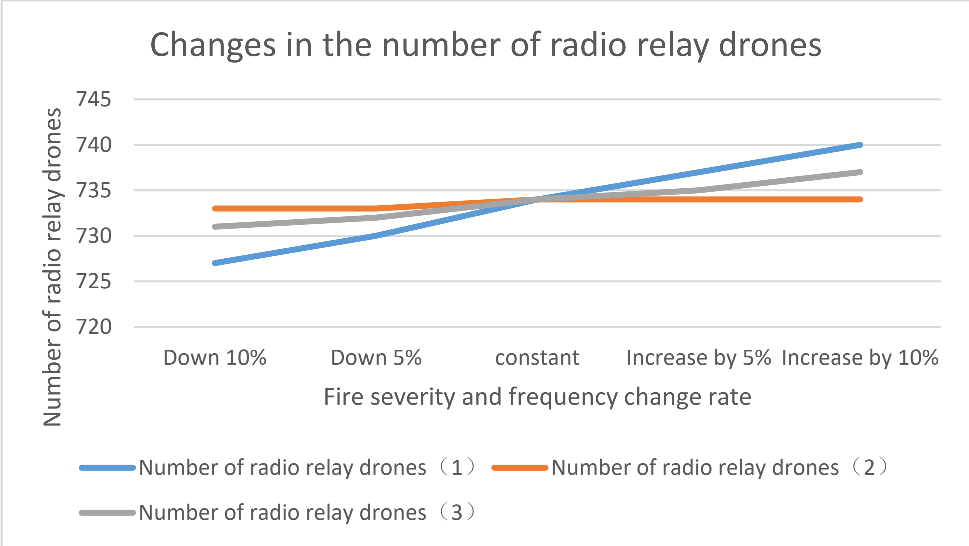

Figure 1: The number of radio relay drones varies with fire severity and frequency

The conclusions are as follows:

(1) With the change of the two parameters of fire frequency and fire degree, the number of radio relay drones changed in line with the actual situation, thus proving the accuracy of the model.

(2) With the fluctuation of parameters, the number of radio relay UAVs in the three groups of data changes in the same situation, and the fluctuation range is not large, thus proving the stability of the model.

3.2 Advantages and disadvantages

Advantages:

(1) "grid processing" is carried out to calculate the relevant data to determine the number of points, mark points, grid, determine the location of the first generation repeater, and finally iteratively determine the location of the high generation repeater.

(2) The data points collected are processed by discretization. Because of the relatively large number of data, and some data points have been almost connected together, the use of discretization method becomes clearly visible.

Disadvantage:

Due to time constraints, inadequate consideration is given to defects affecting altitude.

3.3 Model improvements

(1) On the basis of existing models, the influence factors of altitude are added to show more closely and the simulation degree is higher.

(2) A clear dynamic analysis of the range and trajectory of the UAV and a more detailed planning model can reduce the estimated cost.

(3) Further streamlining of the model to facilitate programming and result.

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