

Optimization Analysis of Emergency Material Distribution Methods Based on Complex Network Model and Cluster Analysis Model

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Abstract. In order to ensure people's normal life, it is especially important to deliver emergency supplies in a timely and accurate manner. Along with the improvement of technology and the gradual popularization of 5G network, the application of drones is becoming more and more widespread, and the delivery mode of "delivery vehicle + drone" has gradually become a new and effective delivery method. The delivery mode of "delivery vehicle + drone" refers to the following: in the process of material delivery, the delivery vehicle delivers to a certain location at the same time, the drone can also deliver to the surrounding feasible locations, and return to the delivery vehicle to reload the materials and replace the battery after the delivery is completed. This distribution mode can greatly improve the efficiency of emergency supplies distribution, and can also solve the distribution of supplies under complex road conditions and avoid secondary damage to people from secondary disasters. This paper is motivated to study the distribution mode of emergency supplies based on complex network model and cluster analysis model.

Keywords: Complex Network Model, Cluster Analysis Model, Optimization.

1. Introduction

In this paper, we use a complex logistics network model to simulate and calculate the optimization effect of using UAVs for delivery routes, and carry out research based on it. Firstly, this paper mainly uses the previous model to numerically simulate the trend of the change of the relevant indexes of the distribution route after the adoption of drone delivery, so that the optimization effect of the distribution route after the adoption of drone can be analyzed and calculated [1]. Secondly, this paper suggests the establishment of a cluster analysis model to analyze and calculate the distribution of the number and weight of the main factors that can be considered to influence the distribution mode of people from two different countries in the geographic area network, and then calculate the optimal configuration of the system [2]. Finally, the plan is to set up two emergency material concentration locations, and if the maximum load is 500 kg, the distribution mode of "distribution vehicle + UAV" is adopted to establish a mathematical model to complete an overall distribution and determine the best location of the two emergency material concentration locations [3].

2. Model assumptions and notation

2.1. Basic assumptions

- 1) Assume all are in the envisioned environment.

2) It is assumed that there are no unexpected accidents [4].

3) It is assumed that the actual operation on the distribution vehicle route can be maintained all the time in a very short time range.

2.2. Description of symbolic variables

The symbolic variables are described in Table 1.

Table 1. Description of symbolic variables

Symbols	Meaning
A_i	Distribution section of the i-th UAV route
B_{ij}	Distribution pressure evaluation score of the ith UAV route in region j
C_{ik}	Distribution mileage of the ith UAV route in region k
D_{ik}	Distribution mileage of the ith UAV route in region k

3. Model construction and solving

Table 2. Raw data

Number	Average delivery time (seconds)	Average Distribution Index	Average delivery mileage (km)
1	290	2751	117
2	108	2662	299
3	103	4910	302
4	105	2052	379
5	219	3407	412
6	221	4358	337
7	201	3224	210
8	196	4575	286
9	180	4675	154
10	165	4991	139
11	140	2820	361
12	256	4518	409
13	108	4856	496
14	192	4192	148
15	295	4925	327
16	155	3781	433
17	139	4761	287
18	285	2403	344
19	146	2947	278
20	135	4908	175

The original data such as (Table 2) can be obtained after comparative analysis of the top 1, 2 and 3 routes are 11, 14 and 6, so the optimal route obtained at the end is: the route it obtained is 9-8-7-1-5-2-3-5-6-4-6-10-14-13-9-12-11-1-7-8-9

3.1. Drones Optimization effect of distribution routes

This paper mainly uses the previous model to numerically simulate the trend of the change of the relevant indexes of the distribution route after the adoption of UAV delivery, so that we can analyze and calculate the optimization effect on the distribution route after the adoption of UAV [5].

We can first consider the unweighted infinite directional network, whose rate of change is given by $\theta_i(t)$ ($i = 1, 2, \dots, N$), which varies with time according to the Kuramoto model.

$$\dot{\theta}_i = w_i + \lambda \sum_{j=1}^N A_{ij} \sin(\theta_j - \theta_i) \quad (1)$$

To facilitate the observation of the synchronization-induced mass change as λ grows gradually, we will now be able to calculate the degree of synchronization speed in each of the N oscillators by using the following formula.

$$r(t)e^{i\varphi(t)} = \frac{1}{N} \sum_{j=1}^N e^{i\theta_j(t)} \quad (2)$$

In order to further study the changes in the frequency of the sequence parameters during the synchronous transition in more depth and comprehensively, the effective frequency can be calculated in the forward continuous transition as follows.

$$w_i^{eff} = \frac{1}{T} \int_t^{T+t} \dot{\theta}_i(\tau) d\tau \quad (3)$$

$$\langle w \rangle_k = \sum_{[i|k_i=k]} w_i^{eff} / N_k \quad (4)$$

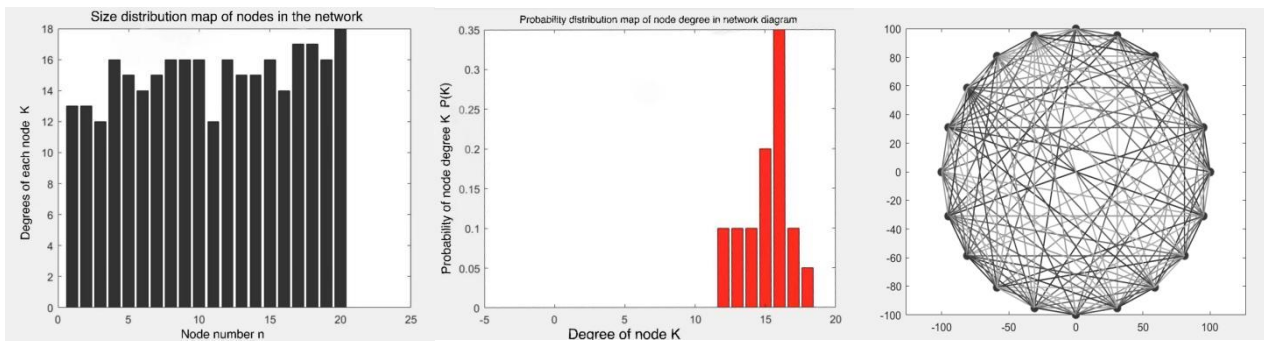


Figure 1. Distribution vehicle nodes and their generation probability, distribution vehicle network generation diagram

Distribution vehicle nodes and their generation probability, distribution vehicle network generation diagram is shown in Figure 1.

Table 3. Changes

Number	Average delivery time (seconds)	Average Distribution Index	Average delivery mileage (km)
1	257	2749	113
2	107	2641	285
3	102	4903	275
4	63	2003	331
5	176	3390	395
6	206	4331	309
7	166	3204	178
8	171	4552	249
9	149	4646	105
10	144	4959	112
11	106	2816	322
12	247	4478	378
13	71	4844	453
14	146	4145	113
15	269	4882	281
16	130	3769	407
17	101	4750	243
18	280	2399	332
19	125	2903	255
20	93	4866	135

We want to use the original data, define a small world network of NW, set each distribution vehicle site as a distribution node, the total number is set to every 20, and the relevant indicators to be considered are set to every 3, which are defined as the time of distribution [6], the mileage of distribution, and the degree of distribution, and the probability of its random variation is about every 0.5, through our analysis of a complex world network of constantly repeated data generation. The analysis of big data can be quickly found to the random variation of its related resource data as Table 3.

Table 4. Distribution pressure evaluation score ranking

Distribution route serial number	Distribution pressure evaluation score	Delivery pressure evaluation scores after opening drones	Drop
11	0.112827615	0.103193041	0.085391982
14	0.108757998	0.100198352	0.078703598
6	0.107633522	0.099134144	0.078965904
2	0.098476036	0.091398315	0.07187252
15	0.094924071	0.09029664	0.048748767
7	0.093942628	0.089692606	0.045240611
1	0.069553855	0.066841424	0.038997562
4	0.068834721	0.066320891	0.036519796
9	0.066351898	0.064706434	0.024799044
18	0.060706663	0.059792398	0.015060377
16	0.060079002	0.059165092	0.015211804
20	0.057911992	0.05771819	0.003346493

Distribution pressure evaluation score ranking is shown in Table 4. The final determination of the optimal at this time, that is: for distribution vehicles 9-6-5-1-7-8-12-9-13-14-10-9, drones 9-10-4-3-2-1-11-12-13-9.

3.2. Optimal configuration of the amount of configuration

In this paper

In this paper, we use a cluster analysis model to analyze and calculate the distribution of the main factors that can be considered in the distribution mode for people from two different countries and geographic areas of the network, and then calculate the optimal configuration of the system [7].

The clustering algorithm used in general is the K-means clustering point method, and the two main steps are:

- (1) select the number of clustering centers
- (2) Calculate the relevant distances and assign the samples randomly
- (3) Calculate the new cluster centers

$$z_j^{(r+1)} = \frac{1}{n_j^{(r)}} \sum_{x \in S_j^{(r)}} x \quad (5)$$

(4) Compare the distance between the newly discovered center and the center of the old discovered cluster, if the difference between the two is closer than the threshold, then they are considered to be identical, if the difference between the centers is higher than the threshold, then it is necessary to reassign them again.

- (5) End of classification and graphing

We then analyzed the weights, the main considerations of the different configurations of regional vehicles and the weights of their choice for comparison and concentration, which can be suitable for its regional more effective and reasonable economic distribution type vehicle comprehensive configuration program [8]. The following table is the actual distribution and transportation situation

of the vehicles in the relevant areas and the actual acceptability of the surrounding people for the current distribution and transportation vehicles. Analysis results is shown in Figure 2.

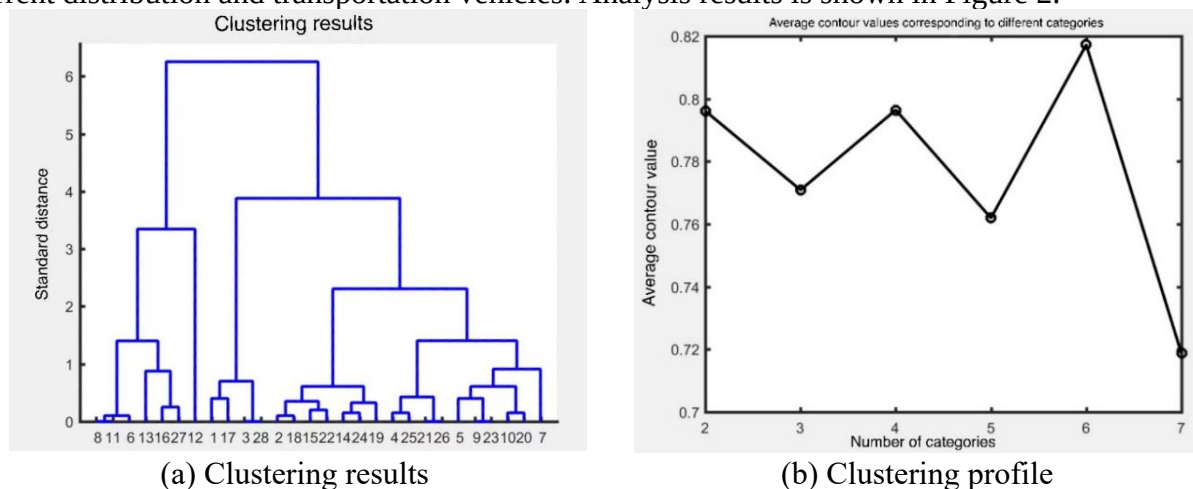


Figure 2. Analysis results

We can conclude from the calculation that the delivery pattern is basically the same as when the load is 1000 kg, but with some modifications, such as the need to remove the drone delivery routes between 14-10 and 2-3.

3.3. Determination of the best location for two emergency material concentration sites

If we can consider choosing the 6th of this month and the 25th of each month as the location of the centralized arrangement of emergency material distribution, according to the current distribution plan to carry out the centralized arrangement of emergency distribution drones, the average conditions of its distribution will seem to improve the degree of full and obvious[9], and its centralized distribution vehicle situation can even reach the original number of vehicles in the centralized arrangement of emergency distribution materials can be reduced by at least 10 unit percentage points more than the original number of vehicles.

From Figure 3 can be more clearly seen, the classification method in the selection of six categories of areas are generally relatively reasonable scientific and reasonable, we can thus get the clustering of relatively concentrated in those six areas, which can then be analyzed. Distribution area data is shown in Table 5.

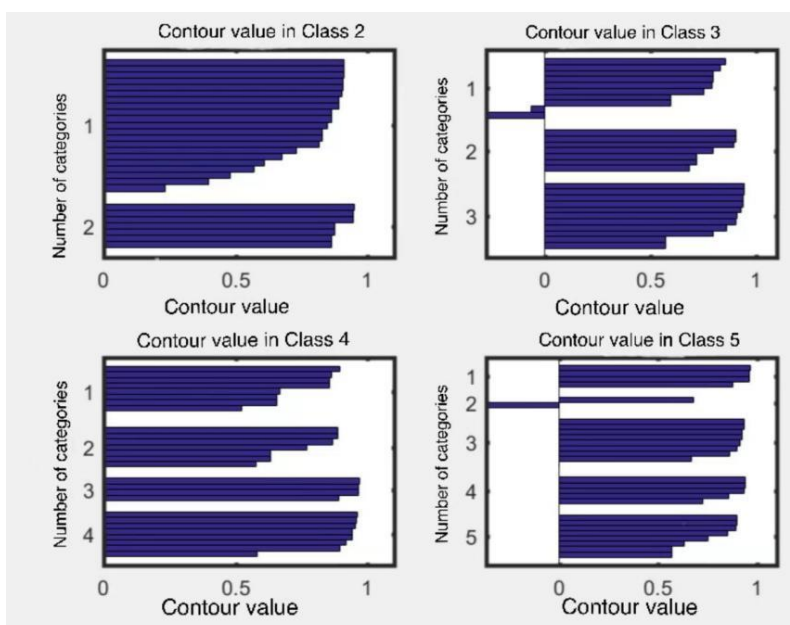


Figure 3. Comparison of clustering profile values

Table 5. Distribution area data

Region	Delivery time	Distribution mileage	Distribution level
5	0.394399603	0.123762459	0.042827586
6	0.571124425	0.41235959	0.956738786
12	0.275042764	0.852885002	0.108079245
16	0.852071602	0.740692357	0.126829149
25	0.882009284	0.106588452	0.124984392
15	0.788031112	0.416909658	0.622741823

A comparison of distribution vehicles was obtained, as shown in Table 6.

Table 6. Number of distribution vehicles

Region	Number of distribution vehicles that should pass through
5	3
6	4
12	5
16	2
25	4
15	3

The above calculation shows that the requirements are well met according to the given conditions. Clustering results is shown in Figure 4.

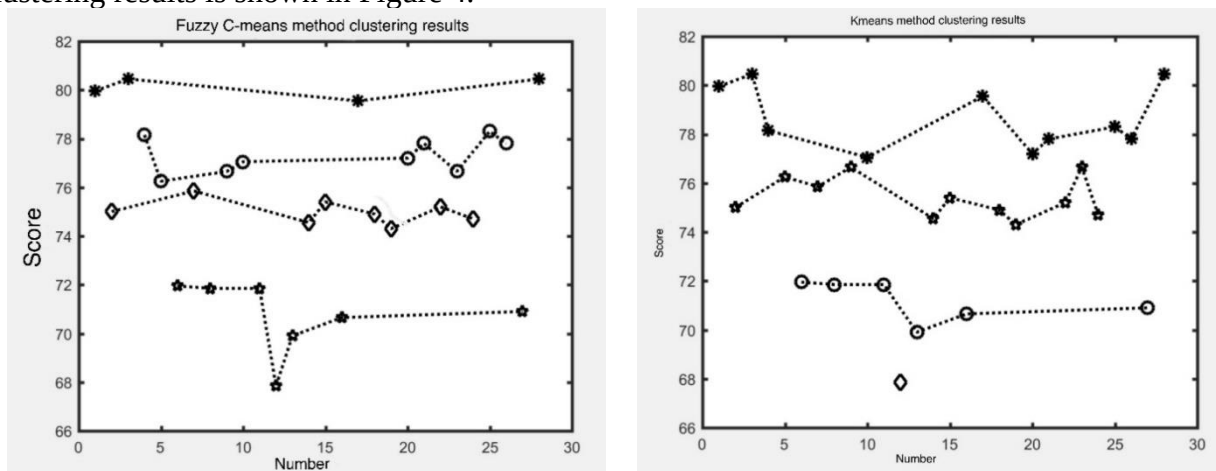


Figure 4. Clustering results

By using the clustering algorithm, the distribution improvement can be calculated, as shown in Table 7.

Table 7. Distribution improvements

Region	Delivery time	Delivery time improvement	Distribution mileage	Distribution mileage improvement	Distribution level	Improvement in the degree of distribution	Average degree of improvement
5	0.3944	0.3848	0.1238	0.1141	0.0428	0.0332	0.215
6	0.5711	0.5626	0.4124	0.4038	0.9567	0.9482	0.532
12	0.2750	0.2665	0.8529	0.8444	0.1081	0.0996	0.206
16	0.8521	0.8450	0.7407	0.7336	0.1268	0.1198	0.123
25	0.8820	0.8774	0.1066	0.1020	0.1250	0.1204	0.625
15	0.7880	0.7838	0.4169	0.4127	0.6227	0.6185	0.170

Through the above proof, and then get 6, 25 good as the material concentration, and according to this set of programs for distribution can meet.

4. Conclusion

When you are faced with a large amount of data Especially when there are many data items, the process of analyzing each group of data separately is tedious [10]. You can divide the market into several categories by the demand and professional needs of the market, so as to achieve a more accurate and delicate analysis. It makes the data which is originally complex and not easy to analyze accurately more orderly and convenient to analyze, simplifying the data

The model developed in this paper can also be applied to issues such as prediction of power system load, and detection of information. It can even be used to further explore the principle law of random motion of the material system in nature with modern pure mathematical means to directly describe and express it, which will have a deep and huge scientific value and realistic mathematical practice guidance significance to further guide our real world social production labor and human life and practice.

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