Design of the Emergency Relief and Road Survey System of Drones

Lu Wang

School of Department of Mathematics and Physics, North China Electric Power University, Baoding 071003, China.

3125856327@qq.com

Keywords: Emergency Relief and Road Survey; Analytic Hierarchy Process; Container Loading Algorithm.

Abstract: In this paper, the design of the emergency relief and road survey system of drones are introduced and the methods used are also explained. Break the problems into three parts. First, use Analytic Hierarchy Process to choose the suitable locations to place the container which carries the drones. Second, according to the locations the first part decided, design the routes that satisfy the need of emergency relief and road survey perfectly. Third, Basing on Standard ISO Container Dimensions and considering the size of containers and drones, use container loading algorithm to give a suitable distribution of medical packages. In the passage, the first and the second part of the system are mainly introduced.

1. Introduction

Always, the nature disaster has caused extensive damage to buildings and roads. In addition, the disaster damaged or destroyed most of the islands cellular communications networks. Worse more, power and battery service disruptions in most parts of the island lasted for several months. Extensive disaster has blocked and destroyed many highways and roads on the island, making it almost impossible for emergency service to be available and to navigate their routes. So that, basic necessities are hard to satisfy, electricity and other facilities are unreliable or completely inaccessible and the use of health care is severely limited. I design the emergency relief and road survey system of drones to ease the emergency.

2. Choose Suitable Locations

2.1 Overview

When it comes to choose the locations to place the containers which are used to load the drones, in which will carry medical packages and devices, we can come up with many ingredients. For instance, the convenience of the transportation, the distance between the location where suffers from the disaster and the location where places the containers having objects they need in it, whether the location is suitable to place the objects or not and so more.

To solve the problems like the above which need to choose the better scheme then the rest, we always use Analytic Hierarchy Process.

2.2 Analytic Hierarchy Process

Using the fuzzy comprehensive evaluation model based on Analytic Hierarchy Process (AHP) can solve the problem of container transportation destination. For more details see [1]. The ingredients that influence the convenience of locating the containers and transporting the packages to the places where needs these materials are as follows:

(1) The distance to the disaster area($B1$);

(2) The convenience of shooting video($B2$);

(3) The distance between two points($B3$);

(4) Physiographic condition($B4$).

And the five locations waited to be chose are expressed as C_1, C_2, C_3, C_4, C_5 and so on.

Using AHP to select the locations to place the containers. Based on empirical judgment, multi-person review, reference literature and other means, we can compare the elements in pairs and obtain the criterion layer judgment matrix and the scheme layer judgment matrix. Then we can obtain the total order of the hierarchy and make a choice.

The steps of AHP are as follows and to see the details in [5]:

(1)Choose the ingredients that influence the convenience of the transportation and make up evaluation system index system collection.

$$U = \{u_1, u_2, \dots, u_n\}.$$

(2)Confirm the value of each indicator.

$$V = \{v_1, v_2, \dots, v_n\}.$$

(3)Determine the weight of each factor.

$$A = [a_1, a_2, \dots, a_n], \qquad and \sum_{i=1}^{n} a_i = 1.$$

(4)Determine the fuzzy synthetic judgment matrix.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \dots & r_{nn} \end{bmatrix}$$

(5)Comprehensive judgment. If have a fuzzy relationship $R = (r_{ij})_{n*m}$ from U to V, we can use R to get fuzzy transformation

$$T_R: F(U) \to F(V)$$

From this transformation, we can get the comprehensive evaluation results$B = AR$.

2.3 Example

Choose Puerto Rico as example. After calculating, the final total order of the hierarchy are as follows:

Criterion Layer		B1	B2	B3	B4	Total sort weight
Criterion layer weight		0.1155	0.2152	0.2659	0.4033	
Scheme layer single sort weight	C1	0.2984	0.3671	0.2018	0.4197	0.3364
	C2	0.1803	0.0707	0.1392	0.1762	0.1441
	C3	0.3848	0.1315	0.1392	0.2766	0.2213
	C4	0.0875	0.0635	0.2387	0.0666	0.1139
	C5	0.0508	0.3671	0.2811	0.0610	0.1842

Fig. 1 Total order of the hierarchy

According to the result, we can see the total sort weight, which suggest the significance of the ingredients we listed forward. So, we can choose C_1, C_3, C_5 three places which rank the top three.

3. Design The Routes

After selecting the three best locations to place containers, route planning is carried out. According to the two routes of locations to disaster area and locations to locations, the route is respectively planned, and the round about method is adopted between the locations.

So that the route should not only meet the needs of the emergency medical package delivery, but also photograph as many roads as possible.

Because of the locations of the containers have been decided, so if we try to choose the routes of the drones, the length of the routes and the density of the road and the density of the aggregation

extent of the disaster area should be considered. For one thing, it is necessary to photograph the condition of traffic such as the roads and railways, and the condition of recovery of the communication system. Furthermore, the situation of the disaster areas is the problem demanding prompt solution. So transporting medical packages and related resources and being aware of the current situation in the disaster area is very important. Basing on the considers above, the routes of the drones can be designed.

Choose Puerto Rico as example. The routes of drones are as follows:

Fig. 2 The Routes

4. Distribution of Medical Packages

We need to consider whether the cargo bay of the drone can contain the emergency medical package needed by the disaster place, and whether the drone can be put into the ISO container. I decide to use packing model to select the suitable type of drone for transportation. And then, I will introduce the container loading algorithm to solve the problems.

4.1 Container Loading Algorithm

The algorithm initially treats the entire container as a space where we can put object in it. Therefore, the initial consideration of this article was how to make the most use of the bottom area of the case, of course, must also ensure its height H within the range of the height of containers.

The flow chart of the container loading algorithm is denoted in Fig 3. For more details see [2-4].

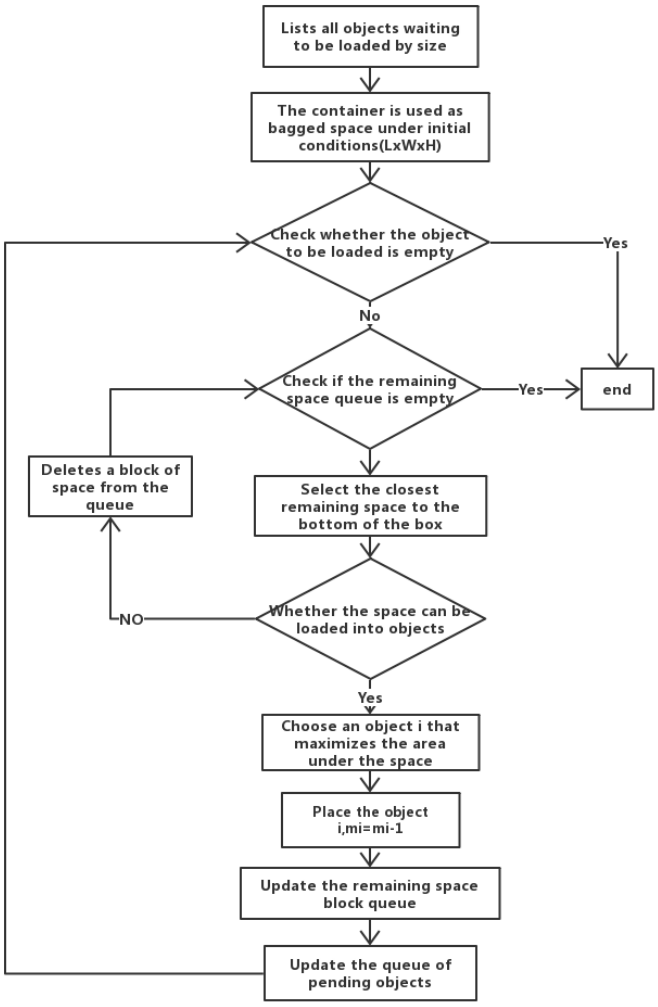

Fig. 3 The Process of Container Loading Algorithm

As saying in reference [4], an important feature of this algorithm is that the placement direction of the object is from bottom to top. By using container loading algorithm, the remaining space in the container after several circulation becomes a complex shape formed by the combination of many cubes. When several blocks of space are adjacent, if they are properly combined, can increase the base area of it, and improve space utilization at the same time.

5. Summary

Choose Puerto Rico as example. Consider the location of the container and the flight path of the drone based on both the delivery of the emergency medical packages and the recording of the road video. First, select the shipping location. Because the disaster area and major roads are concentrated in the northern and eastern parts of Puerto Rico, I select five coastal locations for lockable vessels in the north and east. Then according to four factors: the distance from the disaster area, the distance from the main road, the distance between the shipping locations and the environmental factors, use the fuzzy comprehensive evaluation model to select three locations.

According to the transportation materials and the roads, I plan the two routes from the freight point to the disaster site and from the freight point to the freight point. Choose the six roads that meet the requirements. According to the type of emergency medical packages required in each disaster area, the size of the emergency medical packages, the type of drone cargo bay, and the size of drone cargo bay, I finally establish the most cost-saving solution that can achieve the goal, that is, the

distribution of emergency medical packages on each road and the formation of the drone. And by using Container Loading Algorithm, we can justify whether the scheme is suitable and how to make full use of the spaces.

References

[1] Wang Yan, Wang Xiuling, Wang Li. Research on UAV power emergency rescue system. Information Technology and Informatization, (2018) No.1, p. 135-137.

[2] Li Yurong. Research on three-dimensional loading of container single box. China Tobacco. NeiMonggol, 2015-12, p. 1626-1636.

[3] You Ying, Wang Jingwei. Research on Container Loading Problem. Computer Knowledge and Technology, Vol. 5 (2009) No. 15, p.3999-4094.

[4] Fan Jianhua, Huang Youqun, Liu Jiamin. Research on Container Loading Algorithm. Journal of Shenyang University of Technology.Vol.24 (2002) No. 4, p. 306-308.

[5] Si Shoukui, Sun Zhaoliang. Mathematical modelling algorithm and application. National Defence Industry Press, 2017, p.375-376.