For office use only

T1 ________________

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T3 ________________

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Team Control Number

1909959

Problem Chosen

B

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Feasibility report on the use of drones in disaster areas

Summary

This paper addresses the DroneGo disaster response system and the best flight path for disaster problems in Puerto Rico. We use the simulated annealing algorithm to find the three optimal placement points of containers, calculate the required drone according to the needs of the medical kit and the drone parameters, and solve the three containers assemblies using the dynamic planning based knapsack problem. By considering the size and demand of the drone cabin medical kit we solve the maximum load package configuration, and design the optimal delivery route and schedule according to the five target locations.

For question B, the latitude and longitude given are marked on the map, and we use MATLAB to solve the distance Si between each other, calculate the farthest distance Sj of each drone, compare the distance, and use the simulated annealing algorithm to determine the most. Arecibo, San Juan, Fajardo three ports are placed containers.

After determining the location and destination of the port, it is transported on a close range basis. According to the parameters of the drone, the medical package demand , finally the maximum amount of drone transport, G1 can be transported for ten days each time, G2 can be transported for five days for three days, C3 can be transported for six days for five days and G3 can be sent for four days at a time.

Considering the disaster relief problem, under the premise of meeting the distance requirements, choose the fastest drone that carries the most medical package. It is necessary to carry out the road detection around the island, and select the three B drones with the longest flight time to detect the road. The G1 and G3 drones at Port Arecibo and Fajardo eventually carry container1 and container2 medical packages to Hospital Pavia Arecibo and Caribbean Medical Center respectively. Similarly, G2 drone carry medical packages to Puerto Rico Children's Hospital, C drones carry medical kit to Hospital HIMA and Hospital Pavia Santurce.

After determining the drones in each port, according to the size of the container drone and medical package, the container remaining space is minimized, and the three containers packaging configurations are solved by the backpack problem.

Key word: Dynamic planning Simulated annealing algorithm Knapsack problem

contents

1.Introduction

1.1 Background

In 2017, the United States was hit by the worst hurricane disaster on record, with the worst damage - on the east and southeast coast of Puerto Rico - and the arrival of the storm not only dealt a heavy blow to the island's residents, but also triggered a series of other natural disasters. It destroyed a large number of power poles on the island and damaged all transmission lines. In addition, the island's information and communication equipment was also destroyed, making it impossible for people on the island to communicate with the outside world and the damage on the island could not be known to the outside world. With all roads on the island destroyed, aid vehicles and supplies could not reach the island in time, leaving the island in desperate need of medical supplies to sustain the people on the island to help themselves.

1.2 Problem analysis

One NGO in particular – HELP,inc. wants to support disaster areas by setting up a transportable disaster response system, and to learn about the disaster situation through drones. The company provides us with various types of drones for our use.

We are trying to help the company establish an effective model—DroneGo of drone into the disaster area, the best path for drone flight planning as well as the best location of load and unload drugs, reasonable to calculate the required number of drone and the carrying container assembly in drugs, with the fastest speed to reach the disaster area, in order to provide timely rescue medical package help, at the same time, on the premise of guarantee the speed we will also consider the rescue of the lowest cost. In addition, we will use the video function of the drone to detect the road, so as to facilitate the command and control center of Help.inc. to carry out the road rescue planning on the ground.

The following is an overall analysis of the problem:

A. First of all, according to the map of Puerto Rico and the longitude and latitude of each location requiring medical kits given in the title, we can determine the location of the disaster area on the map, and use MATLAB software to determine the distance between any two points; Because the speed and time of the drone are limited, the maximum distance that the drone can fly without load can be calculated. By comparing the two distances, the drone that meets the distance requirements can be calculated. According to the type and quantity of medical kits required by each region, and the size of drone cargo bay type, the drones that meet the requirements are selected again. Finally, we will select the drones with the highest speed and the largest Max payload capability among the selected drones as the best drones needed in the disaster area. Because of the survey of the disaster area, we will select the corresponding survey drones based on the terrain of Puerto Rico to form the drone fleet.

B. According to the above distance problem, the distance that the drone can fly is limited. If the container is placed in only one or two ports, the drone will not be able to deliver the medical kit to the five required locations, so we chose to place three ISO freight containers in three different ports.

C. For shipping container loading problem, combined with the placement determined in b of the shipping container port location and a required drone of each region and the proportion of medicine package, according to the dynamic programming knapsack problem. We obtained the number of the most pharmaceutical packages under the remaining space in ISO containers

D. The above has determined the port location of the three containers and the type of drone of the drone fleet, and combined with the number of medical packages and drone weights required by the disaster area to determine the payload packaging configuration of the drone; The delivery route is determined by the location of the corresponding container and the location of the required medical package disaster zone; the flight schedule and flight route of the drone determine the timetable

E. To ensure that Help,inc. 's command and control center can timely plan road rescue on the ground, We will deploy one of our fastest and longest-flying drones a day in three ports to survey major damaged roads in Puerto Rico, choose different points on the map using simulated annealing algorithm to obtain a better route, because the annealing algorithm for the problem has some defects, we will eventually to slightly modify the route, ensure the shortest flight distance and the fastest time, so that the road condition information can be conveyed to the command and control center of Help,inc. in time.

2. Symbol Description

E(i) is the sum of the distances from Hospital HIMA, Hospital Pavia Santurce, and Puerto Rico Children's Hospital when the temperature is T.

P is the probability of selecting the current position as the location of the container.

R is the radius of the earth, and the available data is 6371km.

3. Model Hypothesis

1. Assume that the drone and drone cargo holds are separately loadable before they arrive at the port and are transported by ship to shore.

2. Assume that the drone's power comes from a hydrogen fuel cell, which has a full fuel weight of only 1.6kg, and the destination will replace the battery after

reaching the destination.

3. The hypothetical aircraft can be replaced with the help of the government of the destination when performing the partial island detection.

4. Assume that the aircraft does not affect its flight speed and flight time after being loaded.

5. Assume that the drone will not damage the body when transporting the drug, and the drug will not be damaged.

4. Model establishment and solution

4.1 Model I and its solution

4.1.1 Location Determination Based on Simulated Annealing Algorithm

From the latitude and longitude information given in the attachment, we determine the location of the required material location on the map, as shown in Figure 1 below:

Figure 1 location of the required medical kit

In order to be able to deliver the first aid package to the city location more quickly, we use the latitude and longitude information given in Attachment 4 to calculate the relative distance between them. The specific implementation process is as follows.

Latitude and longitude of the two points are known, and two points are obtained. When the distance is not far, the drone is used. Let the longitude be ‘a’ degree, the latitude be ‘b’ degree, and the latitude and longitude of point ‘A’ be A=(α_1, β_1), ‘B’ point latitude and longitude is B = (α_2, β_2), then the distance between the two points of AB in the east-west direction is:

$$x_{AB} \cong \left[R\cos\left[\frac{\beta_1+\beta_2}{2} \frac{\pi}{180} \right] \right] \left[\frac{\pi}{180}(\alpha_1-\alpha_2) \right] \tag{1.1}$$

The distance between two points of AB upward along the south and north：

$$y_{AB} \cong R(\beta_1-\beta_2)\frac{\pi}{180} \tag{1.2}$$

The straight line distance between two points of AB is

$$x_{AB} \cong \left[R\cos\left[\frac{\beta_1+\beta_2}{2} \frac{\pi}{180} \right] \right] \left[\frac{\pi}{180}(\alpha_1-\alpha_2) \right] \tag{1.3}$$

We used JAVA language programming to find the distance between five cities, as shown in Table 1 below：(The relevant program can be found in the attached Distance.java file)

Table 1 Relative distance of the affected area

Location and distance between locations（km）	Caribbea n medical Center Jajardo	Hospita l HIMA San Pablo	Hospital Pavia Santurce San Juan	Puerto Rico Children's Hospital Bayamon	Hospita l Pavia Arecibo Arecibo
Caribbean medical Center Jajardo	0	41.99	46.03	55.44	115.14
Hospital HIMA San Pablo	41.99	0	24.85	24.30	79.03
Hospital Pavia Santurce San Juan	46.03	24.85	0	10.50	69.77
Puerto Rico Children's Hospital Bayamon	55.44	24.30	10.50	0	60.70
Hospital Pavia Arecibo Arecibo	115.14	79.03	69.77	60.70	0

The maximum flight distance when the drone is unloaded by Attachm 2 is shown in Table 2 below：

Table 2 maximum flight distance of drone

Drone	A	B	C	D	E	F	G
Maximum flight distance (km)	23.33	52.67	37.3	18	15	31.6	17.067

We chose to place three containers at the listed ports, because the port is better place to unload containers compared to other places. After we have consulted the information, there are eleven large ports in Puerto Rico. From Table 1 and 2, It is impossible to travel from one city of any other four cities given the load capacity the load capacity of the existing drone. When two ports are selected to place the container, it is difficult to achieve disaster relief tasks. We divided the five affected areas into three areas to place the three containers we selected.

As can be seen from Figure 1, the position of A and J is relatively distant from the five locations. We define them as Area 1 and Area 3 respectively. The three cities of San Pablo, San Juan and Bayamon are relatively concentrated as the second area.

We found that for a region, the port of Arecibo in Arecibo is about two kilometers from Hospital Pavia Arecibo. The port of Fajardo in the city of Jajardo is also about two kilometers away from the Caribbean medical center. The container can be placed in these two locations to achieve quickest rescue. Time rescue, so the chosen location is reasonable.

For the second area, we found a port to reach the three locations of Hospital HIMA, Hospital Pavia Santurce, and Puerto Rico Children's Hospital for rapid rescue. We used a simulated annealing algorithm based on the predictive estimation model. In order to find the port where the ship docked, we defined Two points, which can more accurately achieve the predicted position, the latitude and longitude of the two points is (18.60N, -66.27W) (18.60N, -65.90W), the following is some analysis in the process of our algorithm implementation,

We will ignore the distance of the port to the target location, and directly use the target location of the corresponding city of the port as the location of the port.

$$P = \begin{cases} 1 \ \ if \ \ E(x_{new}) < E(x_{old}) \\ \exp(-\frac{E(x_{new}) - E(x_{old})}{T}) \ \ if \ \ E(x_{new}) \geq E(x_{old}) \end{cases} \tag{1.4}$$

P is the probability of selecting the current position as the position of the container, the initial temperature T=1, the cooling coefficient d=0.99, the final temperature eps=0.00000001, the initial probability of adopting the new solution TT=1.0, and the change coefficient of the adoption of the new solution dd=0.98 Distance function: E(x)

Pleasse note that: Since the change of the latitude and longitude has a great influence on the change of the distance, the initial temperature is set to 1.

When the new location selected achieves a smaller the sum of the distances of the last three cities that arrived at HIMA, Hospital Pavia Santurce, and Puerto Rico Children's Hospital, the current point is adopted as the newly selected container placement point. If it is the opposite, decide whether to adopt this new location to obtain the container placement point for the new election according to a certain probability.

Finally, we determined that the latitude and longitude to place container in the second area is (18.43N, -66.07W) (we implemented this algorithm through java language programming, the specific source code can be found in the Main.java file in the attachment). Even for the city that is farthest from this point, it is within a drone's reach. Therefore, it is reasonable to find the location to place the container.

4.1.2 Result analysis

First of all, we choose the port as the place of container installation, because the port has great benefits for the smooth berthing of the ship, the loading, unloading, storage and transportation of the cargo. In addition, the port can also provide corresponding services and maintenance for the ship.

For one and three regions, we have chosen the port of Arecibo and Fajardo, the port closest to them. The drones can be transported in the shortest time for the Caribbean medical Center and the Hospital Pavia Arecibo transport kits, and can provide road network monitoring.

For Zone 2, we estimate the latitude and longitude of the location of the container by simulated annealing algorithm (18.43N, -66.07W), so that the final location is the closest to the sum of the distances of all the city locations in Zone 2, so it is close to A location of the optimal solution.

4.1.3 Error Analysis

The model error mainly comes from calculating the distance between the target cities by using latitude and longitude and using the probability estimation algorithm to determine the position. Using latitude and longitude to calculate the distance between cities is suitable for cities with only short distances, that's why it may bring some data errors; simulated annealing algorithm uses a certain probability to get the global optimal solution, if the control coefficient is not set in a very suitable situation, it is possible to bring certain errors to the determination of the final position. After coefficient debugging, our coefficient is very reasonable. It is well know that that the simulated annealing algorithm has been proved to be a global optimization algorithm that converges to the global optimal solution with probability. The error is within our acceptable range

From this, the three locations we selected as the container placement location are close to the optimal solution.

4.2 Establishment and solution of model II

Above we have obtained the port location, then we will combine the configuration function and performance of each type of drones in Annex 2 according to the distance between the port and the target location and the daily medical package requirements for each location given in Annex IV. Under the premise of ensuring that the drone can transport the demand of the daily medical kit to the target location, the corresponding drones are selected with the goal of "fastest speed", "having video function" and "maximum payload function".

After the drone is selected, the proportion of the three medical kits in the medical package is determined according to the demand for the medical kit at each target location.

4.2.1 Model establishment

We will discuss the three regions separately.

1. Consider the second area first because it has more target locations and is more complex than the other two areas.

In order to facilitate the analysis, we cut out the two regions as shown in Figure 2 below:

Figure 2 Area 2 enlarged view

In the picture, the yellow stars are the port locations, the three red surfaces are San Pablo, San Juan and Bayamon, and the black arrows indicate the direction of drone transport.

a. First analyze the port to Bayamon, Bayamon area. The drugs required by Annex 4 are two MED1, one MED2, two MED3, according to the size of the drone Cargo Bay in the cabin and the size of the medical kit provided in Annex V. There may be liquid in the medical package, so it can't be inverted, but the length and width can rotate with each other. Therefore, the drone that can send the medical package for the Bayamon area should be equipped with the second cabin, therefore, the C, E, F, G type drones meet the requirements.

Taking into account the distance problem, the distance from the port to the Puerto Rico Children's Hospital Bayamon was 10.5km from Table 1. According to Table 2, the drones in the C, E, F, and G models all meet the distance requirements, because it is a rescue problem. After ensuring that the drone can deliver the drug to the target location, the priority is speed, so that the medical package can reach the target location as quickly as possible to help the disaster area. Compare the above four types of drones, we find F flight the fastest, C, G, and E is the slowest, although the F-type drone is fast, but does not have high-resolution video of damaged and serviceable transportation road networks to HELP, inc.'s command and control center for ground-based route planning, so we don't consider F; For C and G, we find that we have the same speed, G is much smaller than C. Considering the space utilization problem, we hope to have more space to install the medical package , and the weight of G is relatively large, and the Payload Capability is relatively large. Since we could shipped more medical packages, so we prefer G-type drones. We found that the weight of the medical bag required for loading a G-type drone into the Bayamon area is 12 lbs. The maximum load of the G-type aircraft is 20lbs, 12lbs <20lbs, so we finally chose the G-type drone to distribute medical kits for the Bayamon area.

b. The type of medical kit required for San Pablo is two MED1, one MED3, and the type of medical kit required for San Juan is one MED1 and one MED2. As the above analysis of the Bayamon area, the machine types that can load these required medical kits. The machine types are C, E, F, G, and the distance from the port to Hospital Pavia Santurce San Juan is relatively close, so we consider using a drone for Hospital Pavia Santurce San Juan after the medical kit is for Hospital HIMA San Pablo Deliver the required medical kits, which not only saves money, but also delivers medical kits more efficiently.

Considering the distance problem, the distance between San Juan Port for the two regions is about 24.85km. In C, E, F, G, only C and F drones meet the requirements, and then calculate the weight of all medical packages. To be 11^{th},the weight of the C-type aircraft is 14 and the weight of the F-type aircraft is 22, which meets the conditions, but the F-type drone has no video reconnaissance function. Therefore, we finally choose the C-type drone for Hospital. Pavia Santurce San Juan, Hospital HIMA and San Pablo transport medical packages.

c. Due to the video survey of Puerto Rico due to the topic, we will select one of the fastest, longest-running and video-capable drones as the survey drone. Under the optimal conditions, only type-B is not available. Man and machine are the most suitable..

d. Through the above analysis, we have obtained a medical kit that will use the G and C drones as the target location for Zone 2, and the B-type drone is used to survey the road conditions. Therefore, we will load one of the B, C, and G drones in the container of the regional second port. Since the drone and transport cabin are separable before the drug is delivered, we will abandon the B Drone Cargo Bay to reduce the space occupied, to give the container more space , according to the required medical package MED1, MED2, MED3 three kinds of proportions to load, the ratio of the medical package required for the three target locations in the two regions is 5:2:3, we use the complete knapsack problem in the dynamic programming algorithm to solve the medical packaging problem of the container, find an optimal solution, so that the proportion of the container Chinese medicine package is close to 5:2:3, because the set of medical packages can better provide a balance of the required number of drugs for the destination.

Find the optimal solution for loading the drug based on the full backpack problem model:

We are going to get the most value W (the volume of medicines put into the container)

That is to

$$\max \sum_{j=1}^{n} P_j x_j \tag{1.5}$$

However, it is limited by the volume of the container and the placement of the drug in the actual situation:

$$\sum_{j=1}^{n} \omega_j x_j \le W \qquad x_j \in \{0,1,\ldots,\infty\} \tag{1.6}$$

Note: ω is the valume, P is the value of the item, W is the volume of the container, and 'x' is the number of medical kits.

The backpack code is implemented in C++.

2. Below we analyze the one area and the three areas.

a. Because the regional and three-region Hospital Pavia Arecibo Arecibo and Caribbean Medical Center Jajardo are geographically discrete, if one drone in the regional two containers is used, the distance requirements can not be met, and the two can be loaded. The drones required for the medical kits in the place are only C, E, F, and G. Compared with the above four types of drones, F is the fastest, C and G are the second, and E is the slowest, but we found that the F-type is unmanned. Although the speed is fast, but it does not have the video capable function, so it is excluded, and C and G are left. We find that under the same speed, G can bear the weight of the medical package, so it can be used on the cabin. Drone Cargo Bay has a higher space utilization, so we prefer G-type drones, and the weights are also met, so we chose G drones to deliver medical kits for those two places.

b. In the same area, we will add a B drone in one area and three areas for video captable.

c. Through the above analysis, we will use a G drone to transport drugs in a region, a B drone for road reconnaissance, and similarly abandon the B drone cabin to reduce the space. The remaining space of the container is loaded according to the proportion of the required medical package. The medical package required for the target area in the area has only one MED1. We use the same method in the same area to calculate the loading of the medical package in the container. The number of MED1 is 3764.

d. In the three areas, we use a G drone to transport drugs, a B drone for road reconnaissance, and the same to abandon the B drone cabin to reduce space occupation. The remaining space of the container is loaded according to the proportion of the required medical package. The medical package required for the target location of the three regions is one MED1 and one MED3. We calculate the loading of the medical package in the container by the same method in the same area. The result of assembly in the container is that the number of MED1 is 2072 and the number of MED3 is 2104.

4.2.2 Analysis of results

Using the above model, we get the type and number of drones required for each area, and the number of medical kits. We will place a container in each area to provide drone fleets and medical packages for the respective areas. Below is our DroneGo disaster response system.

Table 3 DroneGo Disaster Response System

Region	Regin one	Regin two							Regin three	
destination	**Hospital Pavia Arecibo**	**Hospital HIMA**		**Hospital Pavia Santurce**		**Puerto Rico Children's Hospital**			**Hospital Pavia Arecibo**	
Drone type	B、G	B、F、G							B、G	
Number of drones	2	3							2	
Type of medical package in ISO	MED 1	MED 1	MED 3	MED 1	MED 2	MED 1	MED 2	MED 3	MED 1	MED 3
Number of medical Package required per day	1	2	1	1	1	2	1	2	1	1
Ratio		MED1:MED2:MED3=5:2:3							MED1:MED3=1:1	
Number of medical package in ISO	3764	2530		1032		1498			2072	2104

4.23 Error Analysis

The use of a full-package algorithm based on dynamic programming does achieve maximum use of container space, allowing more medicines to be loaded into containers, but this model is not accurate enough for area 2 and area 3 to achieve the desired location. The proportion of the types of drugs may be such that a certain kind of medicine is theoretically loaded too much, in the actual loading process, the items loaded into the container may be loaded due to the angle problem. Not enough of this theoretical value.

4.3 Establishment and solution of model three

The above has determined the location of the DroneGo disaster response system and the three containers. When the drone arrives at the port, the medical package is delivered to each target location according to the drones corresponding to the three areas in Table 4. We will deliver as much as possible of the type of medical kit required at the target location within the payload of the drone, allowing the drone to deliver more medicine in fewer days.

4.3.1 Model III establishment

1. Payload packaging configuration

The cabins of all the drones we use are number 2, which is 24 inches long, 20 inches wide, 20 inches high and weighs 20. The fifth is the size of the medical kit, as shown in the table below:

Table 4 Emergency Medical Package Configuration/Dimensions

Emergency Medical Package Configuration		
Package ID	Weight (lbs.)	Package Dimensions (in.) (L × W × H)
MED 1	2	14 × 7 × 5
MED 2	2	5 × 8 × 5
MED 3	3	12 × 7 × 4

a. For Zone 1, the required medical kit is one = one type per day, 14 inches in length, 7 inches in width, 5 inches in height, 2 in weight, using G-type drone to transport drugs, drone cargo compartment According to the weight calculation, you can load up to ten types of medical kits, as shown in the following figure 3. Regardless of the height, one No. 2 cabin can carry three No. 1 medical kits, and the cabin height is four times that of the No. 1 medical kit, so the most We can hold 12 No.1 medical kits. Considering the weight, we finally decided to deliver ten medical kits to the region one day, which is ten days.

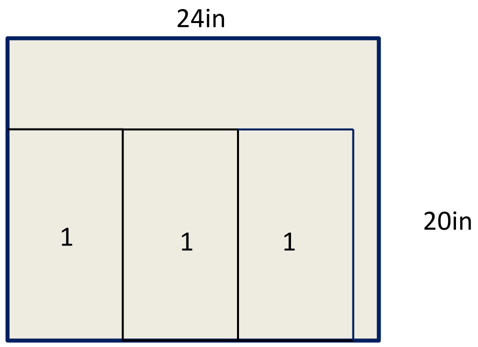

Figure 3 Plan of the No. 1 medical package in the second cabin

b. For Zone 2, the required medical kits for the Bayamon area are two types-one day, one type-two, two types-three. Considering the weight, the second cabin can transport up to two medical kits two at a time. Two No.1 medical kit and four No. 3 medical kits, or six medical kits for the first, one medical kit No. 2, and two medical kits for the third. The size of the medical kit is shown in figure 4. As shown in the figure below, the cabin height of the second cabin is 20 inches. It can transport the medical kits of the two delivery schemes just mentioned.

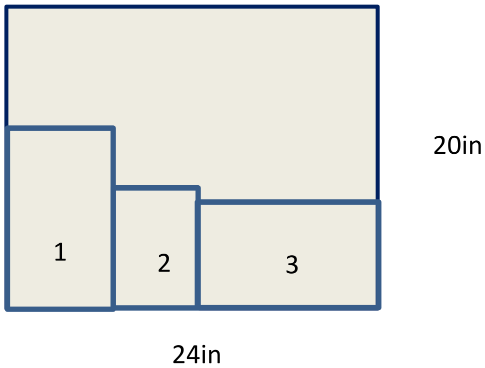

Figure 4 Plan of the medical kit required to load Bayamon in the second cabin

Therefore, we can use three days as a cycle, and the three-day drone G can transport the medical kits needed for five days.

San Juan and San Pablo medical kits that we chose to ship with a C drone. The medical kits required for these two regions are three MED1s, one MED2 and one MED3. Considering the weight, the drone weight of C is less than 14, and you can load three MED1, one MED2 and one MED3 per day, one MED1 in the first three days, one MED2 on the fourth day, one MED3 on the fifth day.

Therefore, we can carry six days of medical package in a five-day cycle.

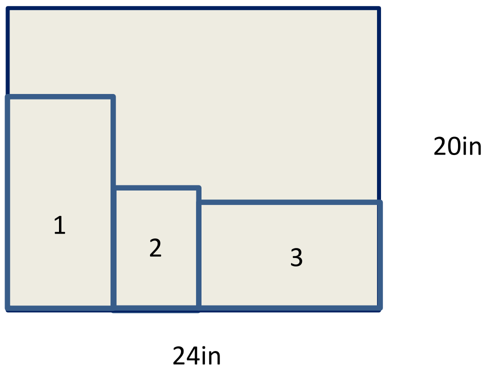

Figure 5 Unmanned aircraft cabin loading plan

b. For Zone 3, the required medical package is one MED1 per day and one MED3. Considering the weight first, the G drone can transport four MED1s and four MED3s per day. As shown below, the size of the second compartment can hold four MED1 and four MED3.

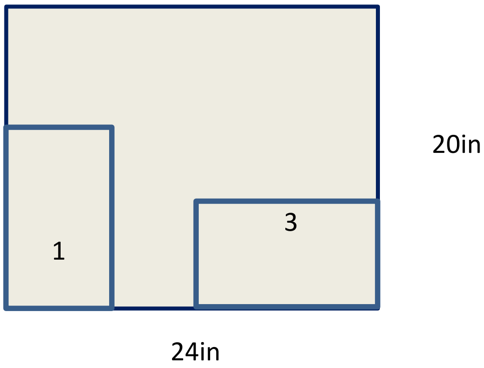

Figure 6 Unmanned aircraft cabin loading plan

2. Delivery route

In the discussion of Model 2 we have already mentioned that an container is placed at the port of Arecibo, and the drone G transports the medical kit for Hospital Pavia Arecibo. An container is placed at the port of Fajardo, and drone G delivers medical kits for the Caribbean Medical Center. An ISO is placed at the port of San Juan, and the drone G transports the medical kit for the Puerto Rico Children's Hospital, which is the Hospital HIMA transport medical kit. The road map is shown below:

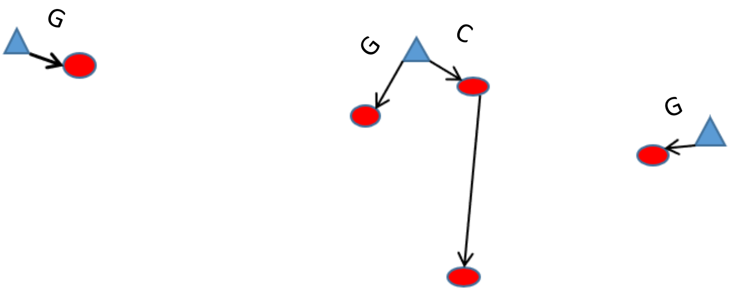

Figure 7 drone drug delivery roadmap

3. schedule

Assuming that at 8:00 a.m., all three ports can fly to their destinations, obviously this assumption is reasonable. According to the distance between different locations calculated by latitude and longitude, we finally get the following timetable for arriving at each location:

target / Time / port	**Caribbean Medical Center**	**Hospital HIMA**	**Hospital Pavia Santurce**	**Puerto Rico Children's Hospital**	**Hospital Pavia Arecibo**
Arecibo port	0	0	0	0	8:01
San Juan port	0	8:23	8:02	8:10	0
Fajardo port	8:01	0	0	0	0

4. Drone flight plan

In order to carry out road rescue planning for the ground in time for HELP.inc.'s command and control center, we use the video capable function of the drone to conduct video reconnaissance on the main roads of Puerto Rico. We also divided Puerto Rico into three areas. Drone B departs from three ports and reconnoiters the area in which they are responsible.

Here we use the simulated annealing algorithm to find some points in the three regions to find the latitude and longitude of these points. The latitude and longitude of the three regions are shown in below. The number of places we leave for the drone is number 1, assuming n points, and finally giving the point number n+1.

A distance matrix $D=\left(d_{ij}\right)_{n*n}$, where the distance d_{ij} , i, j = 1, 2, ..., n, where D is a real symmetric matrix. Then the problem abstraction is to start from point 1, go through all the intermediate points, and reach the shortest path of point n.

The conversion of latitude and longitude to distance has been explained earlier and will not be repeated here.

(1) Solution space S : The solution space S can be expressed as a circular arrangement of all fixed starting points and ending points of 1, 2, ..., 101, 102, namely:

$$S=\left\{\left(\pi_1,\ldots,\pi_n\right)\middle|\pi_1=1,(\pi_2,\ldots,\pi_{n-1}\ n\in 2,3,\ldots,n-1)\,\pi_n=n\right\} \qquad (1.7)$$

each of the loops represents a loop that reconnoiters n-1 targets, and π_i=j indicates that at the reconnaissance j, the initial solution can be selected as (1,2,...,n). In this paper,.

(2) Objective function: The objective function at this time is the path length or cost function for scouting all targets. We ask $\min \mathrm{f}\left(\pi_1,\ \pi_2,\ldots,\ \pi_n\right)=\sum_{\mathrm{i=1}}^{\mathrm{n-1}}\mathrm{d}_{\pi_{\mathrm{i}}\pi_{\mathrm{i+1}}}$ an iteration consists of the following three steps.

(3) Generation of new solution:

2 transformation method: optional sequence u, v (u < v) exchanges the order between u and v, the new path at this time is $\pi_1\ldots\pi_{u-1}\pi_{v+1}\ldots\pi_{u+1}\pi_u\pi_{u+1}\ldots\pi_{\mathrm{n}}$

3 transformation method: optional serial numbers u, v and w, after inserting the path between u and v into w, the new path corresponding to (set u<v<w) is: $\pi_1\ldots\pi_{u-1}\pi_{v+1}\ldots\pi_w\pi_u\ldots\pi_v\pi_{w+1}\ldots\pi_{\mathrm{n}}$

(4) Cost function difference: For the 2 transform method, the path difference can be expressed as $\Delta\mathrm{f}=\left(\mathrm{d}_{\pi_{u-1}\pi_v}+d_{\pi_u\pi_{v+1}}\right)-\left(d_{\pi_{u-1}\pi_u}+d_{\pi_v\pi_{v+1}}\right)$

(5) Acceptance criteria $P=\begin{cases}1\Delta f<0\\ \exp(-\Delta f/T)\Delta f\geq 0\end{cases}$

If Δf <0, accept the new path. Otherwise, the new path $\exp\left(-\Delta f/T\right)\Delta f$ is accepted with probability, that is, if any random number $\exp\left(-\Delta f/T\right)\Delta f$ between 0 and 1 is accepted.

(6) Cooling down

Using the selected cooling coefficient α to cool down, that is, T←αT, a new temperature is obtained, where we take α=0.999.

(7) End condition

Use the selected termination temperature $e=10^{-30}$ to determine if the annealing process is complete. If T < e$, the algorithm ends and the current state is output.

We use drone B to detect the main route displayed in the map, and obtain the offline planning diagram of Area 1, Area 2 and Area 3 according to the simulated annealing algorithm as shown in the following figure

.

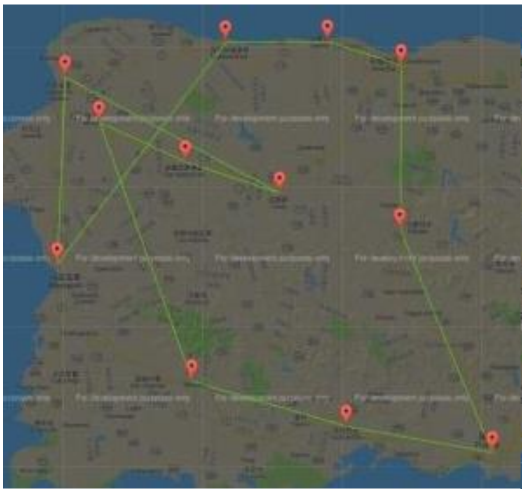

Figure 8 Area One Flight Route

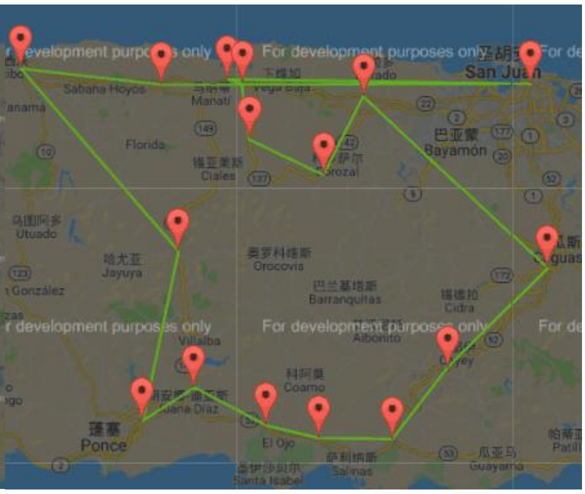

Figure 9 Area Two Flight Route

Figure 10 Area Three Flight Route

As can be seen from the above three figures, although the simulated annealing algorithm can find the shortest distance of each point, it does not completely cover all the main roads, so we have slightly modified it on the map, the result is shown below..

Among them, the black part on the far left is the flight route of area one, and drone B departs from the port of Arecibo and finally returns to the starting point. The red part in the middle is the flight route of the second area. The drone B departs from the port of San Juan and finally returns to the starting point. The blue part on the far right is the flight route for area three. The drone B departs from the port of Fajardo and finally returns to the starting point.

Figure 11 Overall Reconnaissance Route

According to the above figure, the first area is 315km, the second area is 302.07km, and the third area is 261.06km. The three drones are 878.13km.

4.3.2 Error Analysis

Observing the image, we can see that there is a certain gap between the ideal route plan and the plan obtained by the simulated annealing algorithm. But in the process of dealing with this classic NP problem, the results obtained are obviously we can receive this error.

5. Evaluation and Model Evaluation and Promotion

5.1 Advantages

1. Our model has a solid mathematical foundation and is easy to operate in practical applications;

2. Our model is easy to understand, has great dexterity, and minimizes application costs;

3. The establishment of the model uses MATLAB programming to simplify the

problem and have certain use value.

5.2 Disadvantages

1. The establishment of the model has certain limitations, and it may have a large error in the promotion to other disaster scenarios.
2. Consider fewer influencing factors and there are a small amount of error in dealing with problems and data.
3. Our model only considers the normal demand for drugs in the affected areas, and does not take into account the situation of serious disasters.

5.3 Promotion

Through the interpretation of the topic, we can easily find that this is a kind of planning problem, which we can achieve through the algorithm. A careful analysis of the models we have built is not difficult to find. This model can be used not only for disaster relief but also for other planning problems. Planning problems are an important branch of operations research, and it plays an important role in solving organizational management man-machine systems.

We can extend the model of this paper to other planning problems, such as: when the site is selected, we must take into account the distance between the raw material area and the service area. This kind of problem can be solved very well by using our model. Although our model has errors in real-world applications, it may be an optimal model.

6. The memo

We built the model to calculate the optimal assembly plan for the container, the fastest delivery time, and the choice of the drone fleet and the best video reconnaissance route. When choosing a drone, we aim to reach the disaster area quickly and understand the disaster situation and the demand for medical kits. In the process of solving, we found that due to the uneven distribution of the affected areas, through calculation, we concluded that we should try to choose a port closer to the affected area or close to the location of the affected area. We use a series of algorithms to calculate the cruise route of the drone to the disaster area, so that not only can the disaster area be communicated to the control command center in time, but also the faulty drone can be processed in time.

By consulting the data, we found that the response model we built has great advantages for disaster relief. We optimize the loading of the container space and transport the drugs to the disaster area as much as possible, considering the endurance of the drone. We arrange the drones in the immediate vicinity of the disaster area and respond quickly in the face of unexpected situations. Since the reconstruction of the disaster area takes a long time, we have to continue to provide support for the disaster area for a long time. Therefore, the endurance of the drone and the number of drones will affect the ability to transport drugs. We hope that the company can solve the problem. The endurance of man-machines will respond to the situation of more complex disaster areas in the future.

From the above analysis, we conclude that the simulated annealing algorithm is used to transport medical kits to the five disaster areas in the three ports of Arecibo, San Juan and Fajardo. We divide the disaster into three areas and use Matlab to solve the distance between the five locations. Parameters of the drone and medical kit We calculated the loading of the container. Since this problem is a disaster relief problem, our variable setting is relatively small, so there is still a relative error in the promotion of the model.

In addition, in the process of solving the problem, we learned that the current endurance of the UAV is still an urgent problem in the industry. Therefore, I hope that your company can develop some UAV supporting facilities to prevent UAVs from being installed. The emergencies that occurred during the disaster relief process.

The design of the model is easy to understand, and it is easy to be accepted in the process of promotion. However, the stability test of the model is still insufficient. We will improve it in the future. I hope your company can adopt our suggestions.

Thank you!

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Appendix

The matlab program that solves the TSP problem with simulated annealing is as follows:

```
clc,clear
load  matlab.txt
x=sj(:,1:2:2);x=x(:);
y=sj(:,2:2:2);y=y(:);
sj=[x  y];
d1=[-65.6500,18.3300];
sj=[d1;sj;d1];
sj=sj*pi/180;
d=zeros(17);
for  i=1:16
for  j=i+1:17
temp=cos(sj(i,1)-sj(j,1))*cos(sj(i,2))*cos(sj(j,2))+sin(sj(i,2))*sin(
sj(j,2));
d(i,j)=6370*acos(temp);
end
end
d=d+d';
S0=[];
Sum=inf;
rand('state',sum(clock));
for  j=1:1000
S=[1  1+randperm(15),17];
temp=0;
for  i=1:16
        temp=temp+d(S(i),S(i+1));
end
if  temp<Sum
S0=S;Sum=temp;
end
end
e=0.1^30;L=20000;at=0.999;T=1;
for  k=1:L
c=2+floor(15*rand(1,2));
c=sort(c);
c1=c(1);c2=c(2);
df=d(S0(c1-1),S0(c2))+d(S0(c1),S0(c2+1))-d(S0(c1-1),S0(c1))-d(S0(c2),
S0(c2+1));
if  df<0
S0=[S0(1:c1-1),S0(c2:-1:c1),S0(c2+1:17)];
```

```
Sum=Sum+df;
else if  exp(-df/T)>rand(1)
S0=[S0(1:c1-1),S0(c2:-1:c1),S0(c2+1:17)];
Sum=Sum+df;
end
T=T*at;
if  T<e
break;
end
end
```

Use the latitude and longitude to calculate the distance between the target locations. Distance.java program is as follows:

```
import java.math.*;
import java.util.*;
import java.io.*;
import java.util.Random;
public class Distance{
static double get_distance(double latitude1,double longitude1,double
latitude2,double longitude2 ) {//已知两点经纬度求地理直线距离
double R=6378137.0;
double radLat1=(latitude1*Math.PI/180.0);
double radLat2=(latitude2*Math.PI/180.0);
double radLog1=(longitude1*Math.PI/180.0);
double radLog2=(longitude2*Math.PI/180.0);
double a=radLat1-radLat2;
double b=radLog1-radLog2;
double                s=2*Math.asin(Math.sqrt(Math.pow(Math.sin(a/2),
2)+Math.cos(radLat1)*Math.cos(radLat2)*Math.pow(Math.sin(b/2), 2)));
s=s*R;
s=Math.round(s*10000)/10000;
 return s;
}
public static void main(String[] args) {
double lat1=18.33;
double lat2=-65.65 ;
double lon1=18.22 ;
double lon2=-66.03 ;
double s = get_distance(lat1,lon1,lat2,lon2);
System.out.println(s);
}
}
```

The Java program for determining the port location using the simulated annealing algorithm is as follows:

```
import java.math.*;
import java.util.*;
import java.io.*;
import java.util.Random;
public class Main{
static double [] lat= {18.33,18.22,18.44,18.40,18.47,18.60,18.60};
static double [] lon= {-65.65,-66.03,-66.07,-66.16,-66.73,-66.27,-65.90};
static double lx=0,ly=0;
static double nowx,nowy,nex,ney,anspx,anspy;
static double get_distance(double latitude1,double longitude1,double latitude2,double
longitude2 ) {
double R=6378137.0;
//Longitude and latitude converted to radians
double radLat1=(latitude1*Math.PI/180.0);
double radLat2=(latitude2*Math.PI/180.0);
double radLog1=(longitude1*Math.PI/180.0);
  double radLog2=(longitude2*Math.PI/180.0);
  double a=radLat1-radLat2;
  double b=radLog1-radLog2;
double                    s=2*Math.asin(Math.sqrt(Math.pow(Math.sin(a/2),
2)+Math.cos(radLat1)*Math.cos(radLat2)*Math.pow(Math.sin(b/2), 2)));
  s=s*R;
s=Math.round(s*10000)/10000;
return s;
}
public static double f(double a, double b) {
double res=0.0;
for(int i=0;i<7;++i) {
res+=get_distance(a,b,lat[i],lon[i]);
}
return res;
}
public static double ans = 1e20;
static void sa(){
ans = 1e20;
double T = 1;
double d = 0.99;
double eps = 1e-8;
double TT = 1.0;
double dd = 0.98;
double res = f(lx,ly);
if (res < ans) {
```

```
ans = res; anspx = nowx;anspy=nowy;
}
while (T > eps){
for (int i = -1;i <= 1;++i)
for (int j = -1;j <= 1;++j) {
double Temp=Math.random();
if ((i!=0 || j!=0) && (nowx + Temp * i <= 18.60) && (nowx + Temp * i >= 18.20) && (nowy + Temp
* j <= -66.04) && (nowy + T * j >= -66.10)){
nex = nowx + Temp * i; ney = nowy + Temp * j;
double tmp = f(nex,ney);
if (tmp < ans) {
ans = tmp;
anspx = nex;
anspy=ney;
}
if (tmp < res) {
res = tmp;
nowx = nex;
nowy =ney;
}
else if (TT > Math.random()) {
res = tmp;
nowx = nex;
nowy=ney;
}}}
T *= d; TT *= dd;
}}
public static void main(String[] args) {
for(int i=0;i<7;++i) {
nowx+=lat[i];
nowy+=lon[i];
}
nowx/=7;
nowy/=7;
sa();
System.out.println(anspx+" "+anspy);
}}
```

The optimal solution algorithm for the backpack model based on the dynamic programming algorithm C++ main function program is as follows：

```
#include<bits/stdc++.h>
using namespace std;
const int MAX_N=2*1e6;
int n,W;
int w[MAX_N],v[MAX_N];
int dp[MAX_N+1];
int ansValue;
void solve_dp(){
for(int i=0;i<n;i++){
for(int j=w[i];j<=sum_Value;j++){
dp[j]=max(dp[j],dp[j-w[i]]+v[i]);
    }
  }
```