For office use only	Team Control Number	For office use only
T1 ________________	**1921453**	F1 ________________
T2 ________________		F2 ________________
T3 ________________	Problem Chosen	F3 ________________
T4 ________________	**B**	F4 ________________

2019
MCM/ICM
Rescue! Life or death?

Hurricane disaster in Puerto Rico in 2017.It's challenging for ngos to respond to the disaster. However,transportable disaster response system,in a short time,can be quickly transported me dical supplies and reconnaissance roads in the disaster area.

Problem A: By using the entropy weight method, with the comprehensive evaluation model established and 3 indexes proposed, the final result can be obtained. The 3 indexes include the utility rate of space, the maximum days medical devices can support and the drones' efficiency to exploding the roads. **The cargo container no.1 contains 4 drone B, 3 drone C,120 MED1, 30 MED2, 120 MED3. The cargo container no.2 contains 3 drone B, 1 drone C, 2 drone F, 90 MED1, 30 MED 2.**

Problem B: By using the centroid method, with the optimization model established and 3 indexes proposed, 6 optimal drop location can be obtained. The 3 indexes include the rate that takes to transport, the distance from the delivery location to the chosen location, and the amount of medical packages every time transport.

By using the optimal circuit method, with the optimal route established and the reconnaissance efficiency as target, the 2 best locations are obtained. Find the best location between the two models' result, 2 positions can be obtained:**(-66.45, 18.37) and (-65.97, 18.33)**

C drones to the container no.1; 3 type B drones and 1 type C drone, 2 type F drones to the container no.2. The video reconnaissance of road networks can be conducted while transporting and the disaster area will be rescued to the maximum extent.

Key words: the comprehensive evaluation model, centroid method, entropy weight method, the optimization model, optimal circuit method.

Contents

1 Introduction

1.1 Background

The hurricane happened in Puerto Rico in 2017 caused severe damages to the local people. In Puerto Rico, over 2900 people died and all residents suffered from power outages.Lots of buildings, houses, and public utilities were destroyed, and the life quality was reduced. Many places have not restored outage yet.When the flood is coming, the highways and roads are blocked, so it seems impossible to find the accurate pot where the medical supplies are needed in an emergency. The casualties caused by disaster made the responsibility for the hospitals increase sharply.The destructive power from hurricanes and waves had been essentially felt by people.

For this situation, the Non-governmental organizations-HELP,Inc had decided to design a transportable disaster response system to help better deal with this kind of emergencies.When the disaster was happening, drones would be sent to the pointed place to transport medical supplies and reconnoitre the road.

A mathematical model for managing the hurricane disaster situation has been proposed in. The model finds a best place to balance both medical supply delivery and video reconnaissance.Meanwhile, the model also finds a most reasonable and optimal way to package the drone fleet and medical supplies into the cargo containers.Moreover, another model has been proposed in to list the time schedule about the time each drone needs to take to arrive at the pointed place.

Figure 1: The situation of Puerto Rico.

1.2 Restatement of the problem

Requirement 1

- Prepare a drone fleet and a set of medical packages that is corresponding to the hurricane in Puerto Rico for the HELP, Inc.DroneGo disaster response system.Package up to 3 ISO cargo containers correctly to transport the system to Puerto Rico.

- Find the best place in Puerto Rico that can transport medical supplies and reconnoitre the road as well as position one, two, or three cargo containers of the DroneGo disaster response system.
- Offer the drone payload packing configurations, delivery route, and time schedule for the demand of the emergency medical packages.
- Make a drone flight plan to have a all-sided look towards roads over the island with the drone fleet.

Requirement 2

- Write a memo to the CEO of the HELP,Inc to share the achievements and the best solution towards to the problem in a popular and easy-to-understand way.

2 Analysis of the problem

- **Analysis of requirement A:**

In the incident of the hurricane happened in Puerto Rico, the chosen medical supplies and the drone fleets would be loaded into the cargo containers in an optimal way. Hence, a comprehensive evaluation index system model was established to make better use of the space of the cargo containers and increase the quantities of the relief goods to the maximum extent so that there would be less casualties in disaster areas and the video reconnaissance can be conducted in a higher speed.

The optimal ways to load the cargos contained a series of objective rules such as sequencing rules of a single cargo, sequencing rules of cargo layers, the sequencing rules of the remaining space and so on. For the practical situation, the rule to drop the containers should also include the size of the medical devices, the model number of the drones and the demand for the medical supplies. Based on these rules, some indicators that can describe the model quantitatively came into being, that were the utility rate of space, the days medical devices can support and the efficiency drones explore the road If linearly combined these indicators, then a function about evaluation can be obtained: Adapt.

Consider the functions combined linearly as objective functions, all the indicators as decision variables, and the volumes of the cargo containers as constraints. Then consider all the ways to load the cargos, calculate the final assessed value and compare them by programs. The optimal way, which is the most appropriate for the actual situation in the disaster area to load the cargos, can be obtained.

- **Analysis of requirement B:**

In order to throw the cargo containers in the required location as soon as possible, the best location should be calculated. And the best location needs to be able to conduct both medical supply delivery and video reconnaissance of road networks. Therefore, two models are established to solve the two tasks. That is, to use the centroid method model (model II) to describe medical supply delivery and optimal route model (model III) to describe reconnaissance of road networks. Take overall consideration for the two factors, the best location to throw the containers can be obtained.

The factors that will influence the model II include the demand of medical supplies in hospital, the maximum payload capacity of the drones and the distance of voyage. The factors that will influence the model include the time of endurance of the drones and the efficiency of scouting.

By analyzing the research status of multi-objective optimization, some objectives can be transformed into constraint conditions, and the multi-objective optimization can be transformed into the single object optimization model. When studying the model II, consider the demand of medical supply as objective function, the relative information about drones as constraint condition. When studying model III, consider the efficiency of scouting as objective function, the distance of voyage as constraint condition. Under a single objective, take overall consideration for the two factors to find the best location to drop the containers.

- **Analysis of requirement C**

The drones will transport the medical supplies and reconnoiter the roads according to the dropped cargo containers. List the effective load with drones. Then plan the drone route to transport the cargos and the time table to transport medical supplies. In the end, find an efficient and fast way for drones to scout the main roads and highways to plan and navigate the large-scaled rescue.

3 General assumptions and symbol description

3.1 General assumptions

- All delivery locations' power equipment is intact.
- Drones are not affected by the weather.
- Medical equipment must not be placed upside down or sideways.
- The cargo hold of the drone has no weight and volume.
- The drone is fully charged when it landed at the hospitals or cargo containers and is not allowed to fly again that day

3.2 Symbol description

Main notations and symbols

Variable	Description
s	the utility rate of the volume
L_i	The length for the ith object
. w_i	The width for the ith object
H_i	The height for the ith object
$Vtotal$	The volume for the cargo container
$X_(ij)$	The data in the ith row, jth column in matrix
$Min[X_(ij)]$	The minimum in matrix
$Max[X_(ij)]$	The maximum in matrix
$K1, K2, K3$	The weight obtained by entropy weight method
$Adapt$	The indexes to measure the adaptation
R	The rate that takes to transport
sum	The total amount of the medical packages
S	The total transportation expense from the delivery location to container location
(x_0, y_0)	The optimal location to choose

4 Modeling optimal packing method

The medical supplies need to be put into the containers in the disaster area in Puerto Rico reasonably to meet the requirement of HELP, Inc. By analyzing the inside size of the cargo containers, the size of drones and the medical devices, the quantity demand that can be satisfied by containers with medical devices in hospitals in a short term can be calculated. Since a container can be loaded with huge quantities of medical supplies, just two containers will be chosen and the amount of drones will increase to devote greater effort to rescue.

4.1 The solution of the model

For this problem, relief goods are put into cargo containers. The cargo containers can be seen as cuboids with reference to the standard cargo containers. The inner place of the cargo containers can be modeled in 3D to find the best solution to place cargos. With the help of the Cartesian coordinate system, a cuboid about 231 inches long, 92 inches wide and 94 inches high is available.

The final layout quality will be influenced a lot by the order of loading during the process of packing. So the order of importance among the attributes of the cargos needs to be set properly. Here shows the sequence on the basis of the degree of importance.

The cargos can also be seen as cuboids in some degree because they are packed in a regular way. They will be numbered as 1, 2, 3...n to put into the containers; each number is corresponding to its length, width, and height.

4.1.1 Sequencing rules

[1]

The final layout quality will be influenced a lot by the order of loading during the process of packing. So the order of importance among the attributes of the cargos needs to be set properly. Here shows the sequence on the basis of the degree of importance.

- The principle of volume decreasing. Cargos with larger volumes are placed first while the smaller ones are placed second.
- The principle of base area decreasing. Cargos with larger base area are placed first while the smaller ones are placed second.
- The principle of the longest edge decreasing. Cargos with larger longest edge are placed first while the smaller ones are placed second.

4.1.2 Sequencing rules of cargo layers

- Obey the rule that loads from bottom to top, inside to out.
- The cargo layers should be sort by the degree of its total importance.

4.1.3 Sequencing rules of the remaining space

- Minimize the remaining space. Search the remaining space every time before loading the cargo, if the space can be utilized and the utility rate of space can be raised, then another cargo can be loaded.[2]

4.2 A comprehensive evaluation index system model for assembling

When describing the containers or the supplies, the volume, which is the space an object contains or occupies, can be transformed into the product of the length, width, and height. The product of the length(L), width(W), and height(H) is seen as the volume to describe the characteristic of an object. Then the utility rate of space in each container can be obtained by using formula (1). The utility rate of space is higher, the method of assembly is better.[3]

$$s = \frac{\sum_{i=1}^{n}(L_i W_i H_i)}{V_{total}} \times 100\% \tag{1}$$

It is easy to calculate the time medical supplies can support in a transport. And the efficiency drones can scout means the ability to find out the extent of the damage for roads and highways, plan and navigate the rescue troops on the ground, give the large-scale medical assistance, and at the meantime, satisfy the needs of medical devices in hospital. In a short term, the longer time medical supplies can support in a transport, or the higher efficiency drones can scout, the fewer casualties there will be.

By using no-dimension analysis to deal with the data, the difference between indicators in dimensions and order of magnitudes can be eliminated. It will be more convenient to compare and analyze the indicators. Then use relative deviation minimum method with formula (2) to deal with the utility rate of space, the time medical devices can support and the efficiency drones explore the road.

$$a_{ij} = \frac{x_{ij} - min[x_{ij}]}{max[x_{ij}] - min[x_{ij}]} \tag{2}$$

Finally,by using reality-based entropy weight method, the weight of each indicator can be known as (K1, K2, K3), and the fitness function below can be obtained. And by using enumeration method and considering all the possibilities, the adequate and optimal way to load the cargos into the containers can be obtained.[4]

$$\begin{cases} \sum_{i=1}^{3} k_i = 1 \\ Adapt = k_1 s + k_2 t + k_3 e \end{cases} \tag{3}$$

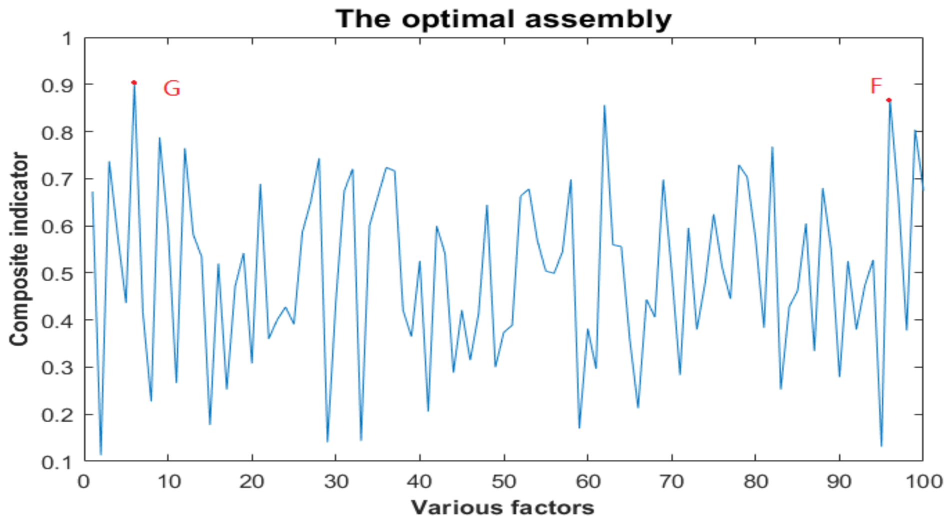


Figure 2: The best solution.

Table 1: Cargo container I.

	Drone B	Drone C	MED 1	MED 2	MED 3
$quantity$	4	3	120	30	120

Table 2: Cargo container II.

	Drone B	Drone C	Drone F	MED 1	MED 2	MED 3
$quantity$	3	1	2	90	30	0

5 Optimal location to drop cargo containers

5.1 Model assumes

The model does not do specific analysis about the different kinds of demands for the medical supplies in each delivery location. The model only analyzes the quantity demand for the medical supplies, as shown in the table below:

Table 3: The quantity of medicine required.

Variety	A	B	C	D	E
Quantity	2	3	2	5	1

From this, the total amount for the requirement of the medical supplies in the 5 delivery locations can be calculated. The sum is equal to 13.

Assume that the topography in the container drop locations has no influence on the drone delivery. That is, to regard Puerto Rico as plane to ignore the influence caused by topography.

The parameter that needs to be used in the centroid method —— the rate that takes to transport, is only relative to the amount of the medical packages, it satisfies the following relation:

$$R = \frac{n}{sum} \tag{4}$$

Thereinto, R is the rate that takes to transport, n is the amount medical packages have loaded into, sum is the total amount of the medical packages.

Ignore the specific contents in the containers and assume that the model can satisfy all the requirements.

- **Fundamentals theory**

The centroid method model, which is based on the calculus, is used to find the solution to minimize the transportation cost between the delivery location and the demand position.For this problem, the map of Puerto Rico needs to be modeled firstly. Consider the longitude -66.00 degrees, the northern latitude 18.00 degrees as the origin coordinates to set up a regular plane coordinate system, and consider 0.01 as the coordinate system's unit calibration. From this, all demand positions can be seen as a series of splashes in the coordinate system, and their positions can be located by coordinates. The demand for the medical supplies in all delivery locations is regarded as the corresponding amount of the medical packages (the n mentioned above), then the best location to drop the containers can be calculated as the centroid of the set of points.

Now begin to introduce the general solution to the centroid method. Assume that there are N delivery locations in total, any position can be expressed into (x_i, y_i) in this coordinate system, and i=1, 2, 3...N. The required objective function, that is the drop position for the containers, can be expressed as (x_0, y_0). The diagram principle is below:

- **Theoretical problem solving**

Set S as the total transportation expenses from the delivery location to all the demand locations, A_i as the amount of the medical packages from the delivery location to some demand location, R_i as the rate that takes to transport from the delivery location to some demand location, C_i as the distance from the delivery location to some demand location.

There out, the total expense from the delivery location to the demand locations can be obtained:[5]

$$S = \sum_{i=1}^{n} A_i C_i R_i \tag{5}$$

And

$$C_i = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2} \tag{6}$$

To find the best x_0 , y_0, the minimum value of S needs to be calculated. There are two unknowns for the function S, that is, x_0, y_0. Then take partial derivatives for S, as follows:

$$\frac{\partial S}{\partial x_0} = \sum_{i=1}^{n} \frac{A_i R_i (x_i - x_0)}{C_i} \tag{7}$$

$$\frac{\partial S}{\partial x_0} = \sum_{i=1}^{n} \frac{A_i R_i (y_i - y_0)}{C_i} \tag{8}$$

Make the values of the two equations above as 0, the expression can be obtained.

$$x_0 = \frac{\sum\limits_{i=1}^{n} A_i R_i x_i / C_i}{\sum\limits_{i=1}^{n} A_i R_i / C_i} \tag{9}$$

$$y_0 = \frac{\sum\limits_{i=1}^{n} A_i R_i y_i / C_i}{\sum\limits_{i=1}^{n} A_i R_i / C_i} \tag{10}$$

Use Matlab to multiply iterate the expressions above, and get the minimum of S. Then the optimal solution (x_0, y_0) can be obtained.

- **Practical problem solving**

In this article, the demand locations determine the object of the container service, as follows:

Assume that the container no.1 is dropped into the area between A, B, C, D, the container no.2 is dropped into the area between C, D, E and they serve for the area. But that's not the case, for the container no.2, the object of the service can only between D, E. Since the demand in D, E can only be satisfied by the container no.2, if the container simultaneously satisfies C, D, E or C, E, it can be known that the container will be dropped into the sea with latitude more than 50 degrees according to the model above, so these two choices should be given up.

The value of n in this article is 5. Because the demand of D can be simultaneously satisfied by the two containers, the value of R_i will change by the medicine delivery scheme for D. There are 6 ways to change, and only the first way is listed in forms below.The rest of them which are calculated refering formula will not be repeated here, as follows:

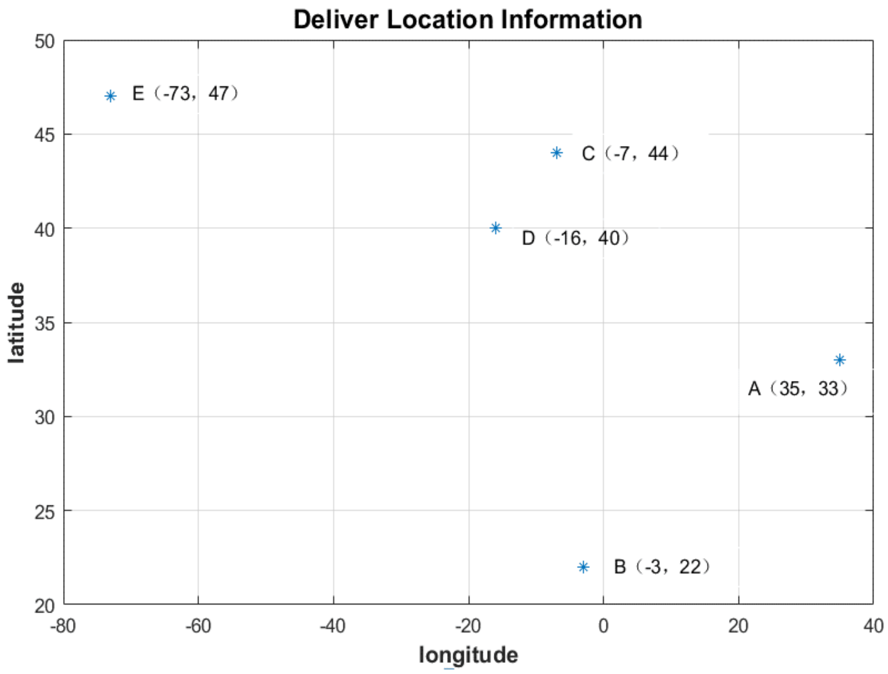


Figure 3: Delivery location information.

Table 4: Assembly of cargo container I.

cargo container I	A	B	C	D
R	1/6	1/4	1/6	5/12

Table 5: Assembly of cargo container I.

cargo container II	D	E
R	0	1

- **Final result**

I. the container no.1 transports 12 medical packages per day; the container no.2 transports 1 medical package per day.

II. the container no.1 transports 11 medical packages per day; the container no.2 transport 2 medical packages per day.

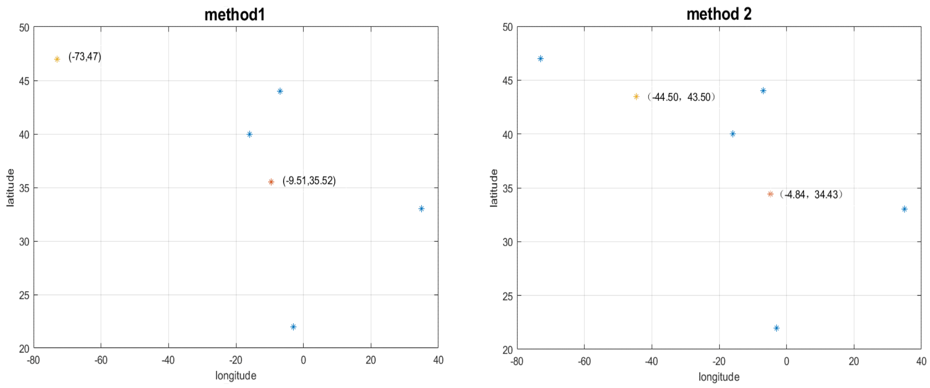
III. the container no.1 transports 10 medical packages per day; the container no.2 transports 3 medical packages per day.

IV. the container no.1 transports 9 medical packages per day; the container no.2 transports 4 medical packages per day.

V. the container no.1 transports 8 medical packages per day; the container no.2 transports 5 medical packages per day.

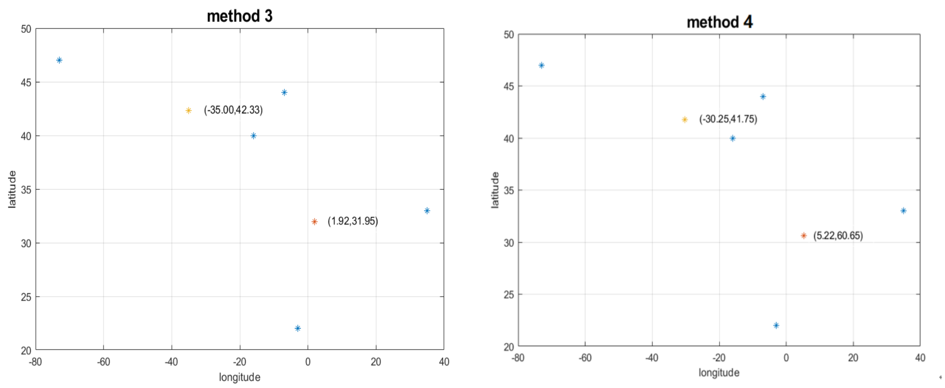
VI. the container no.1 transports 7 medical packages per day; the container no.2 transports 6 medical packages per day.

All these 6 ways are the best solutions in each's condition. The best solutions can be obtained as follows:



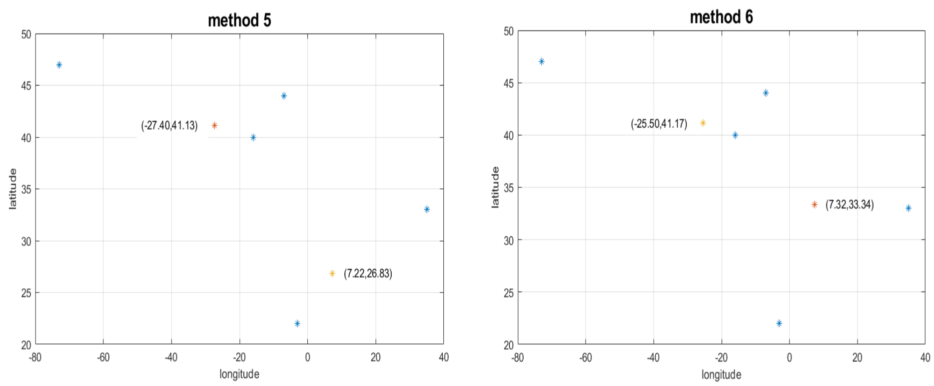
(a) (b)

Figure 4: method I (a) and method II (b)



(a) (b)

Figure 5: method III (a) and method IV (b)



(a) (b)

Figure 6: method V (a) and method VI (b)

5.2 The optimal route model

In this model, the times that have decreased for the repetitive reconnaissance of road segments are the decision variables; the reconnaissance efficiency reflected in the optimal route is the objective functions; the maximum time of endurance for drones is the constraint condition. The optimal drone reconnaissance route should consider all these conditions. For the cargo container I , there are fewer main roads around, therefore, on-

$$a=\begin{cases}(-9.51,35.52)\\(73.00,47.00)\end{cases}\quad b=\begin{cases}(-4.84,34.43)\\(-44.50,43.50)\end{cases}\quad c=\begin{cases}(1.92,31.95)\\(-35.00,42.33)\end{cases}$$

$$d=\begin{cases}(-30.25,41.75)\\(5.22,60.65)\end{cases}\quad e=\begin{cases}(7.22,26.83)\\(-27.40,41.13)\end{cases}\quad f=\begin{cases}(7.32,33.34)\\(-25.50,41.17)\end{cases}$$

Figure 7: The optimal solution under the model.

ly a few drones can finish the task for the road reconnaissance when transporting the medical devices. But for the cargo container II, the circumjacent circumstances of the roads are more complex, so there are higher demands for the amount of the drones and the distance of the voyage. The optimal route for the drones will be planed considering all these facts.

By using single objective optimization model, considering other factors as constraint conditions, the restriction from central variable is highlighted. Now stipulate that in a flying route, the same location can't appear twice, that is, the drone can't arrive the same location repeatedly, it will be easily satisfied in general cases.[6]

$$min\sum_{i=1}^{m}\sum_{j=1}^{n}w_{ij}x_{ij} \tag{11}$$

It's calculated according to the formula that among all the points in the map, the values of g$(-45.56, 37.07)$ and h$(2.67, 33.09)$ are the minimum. So these two locations are the best place to scout the roads and they are the most efficiency.

- **Final result**

To choose the optimal location to drop the containers, the medical supply delivery and video reconnaissance of road networks are of equal importance, so they are given the same weight. So taking overall consideration for the final results to the two models, the two adequate locations can be obtained. As the follow picture shows(Figure 8):

5.3 Transportation and reconnaissance of drones

After taking overall consideration of the model II and the model III, the best drop places can be obtained, that is g$(-66.45, 18.37)$and h$(-65.97, 18.33)$. They conduct both medical supply delivery and video reconnaissance efficiency. Because the drone cargo bay is big enough to satisfy the demand for a transport, the medical packages with the same weight needn't to be finely classified. To simplify the assemblage, the medical package 3 will be canceled to transport in the cargo container II, so the proportion of the medical packages is that:cargo container I, M1:M2:M3=4:1:4; container no.2, M1:M2:M3=3:1:0.

After the analysis based on the main delivery routes, the main delivery routes and the reconnaissance routes can be regarded as objective function, as the following picture shows:

Because the delivery routes are relative to the time table and the configuration of drone effective load, and that when the delivery routes are confirmed, the time table

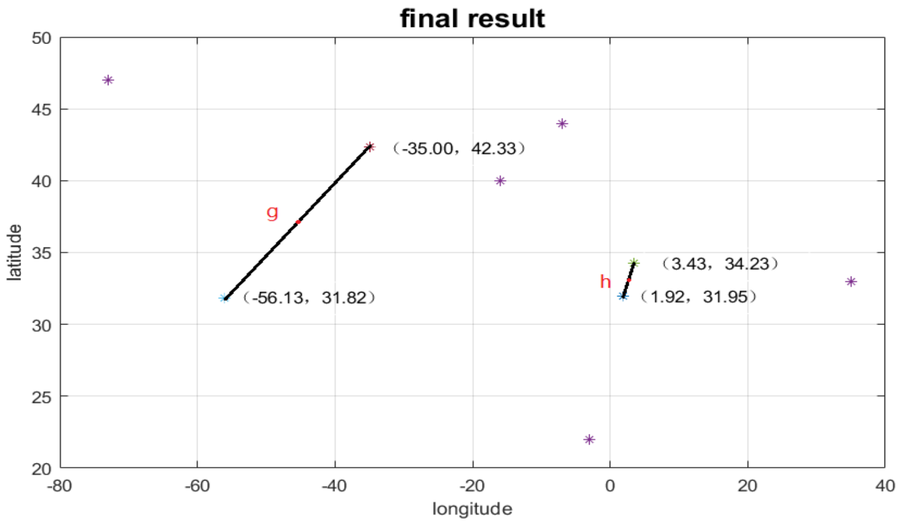


Figure 8: The two best locations.

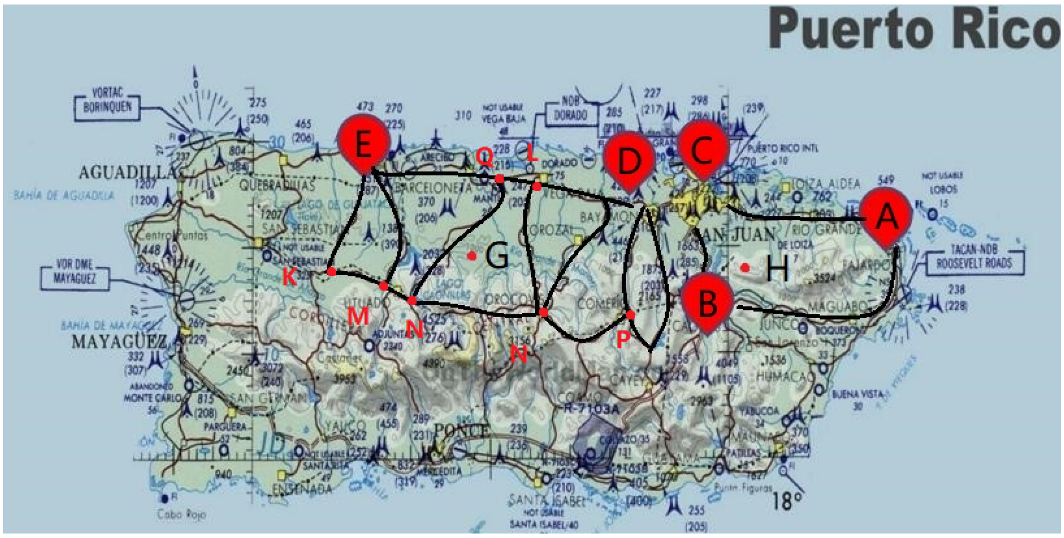


Figure 9: Road map.

and the configuration of drone effective load can be confirmed, in this article the best solution will be obtained by optimizing the delivery routes.

The Euler loop model is established. For a Unicom figure, usually calls the route comes from the starting point continuously as Euler route, and calls the route that can came back to the starting point continuously as Euler circuit.

For container no.1, 4 triangular circuits can be established with the 4 demand locations and the main roads for reconnaissance. And for each "triangle", the distance for each side is shorter than the max voyage distance for drones. From this, only 3 Euler loops need to be passed to return to the starting point for each "triangle". According to the model, each optimal configuration of drone effective load and the time table can be confirmed.

For a single point, the effective load should satisfy the equation below:

$$iB_{carry} + jC_{carry} \geq 3dailydemand \tag{12}$$

Thereinto, B_{carry}, C_{carry} are the medical packages carried, i, j are the amount of the drones, dailydemand is the daily demand in the location.

Drones were sent from drop point for cargo containers to hospitals where needed the medical supplies. whether the medical supplies would be accurately arrived, the payload weight of the drone was taken into account. Because of that, the information of drones was listed in the table below.

Table 6: Uav packaging configuration.

Drone type	Drone B	Drone C	Drone F
$Payload\ weight(Ibs.)$	4 and 7	2 and 6	4, 5 and 6

5.3.1 Delivery route and schedule

Drone F with MED 1 was dispatched from Drop point for cargo containers, G, to demand point, E. And Drone F with two MED 1 and MED 2 was dispatched from Drop point for cargo containers, G, to demand point, D.

Drone B with MED 1 and MED 3 was dispatched from Drop point for cargo containers, H, to demand point, A. Drone B with two MED 3 was dispatched from Drop point for cargo containers, H, to demand point, D. Drone C with MED 1 and MED 2 was dispatched from Drop point for cargo containers, H, to demand point,C. Drone C with two MED 1 and MED 3 was dispatched from Drop point for cargo containers, H, to demand point, B.

Table 7: schedule of cargo container I.

The path	G→E	G→D
$t(min)$	18	20

Table 8: schedule of cargo container II.

The path	H→B	H→C	H→D	H→A
$t(min)$	10	20	15	25

5.3.2 Uav flight plan

In cargo container I, drone B was used in the H→B→A→H, H→B→A→H and H→D→P→D→H. Drone C was used in the H→C→B

In cargo container II, drone B was used in the G→Q→E→K→M→G, G→E→E→M→N→G, G→Q→L→P→G, G→L→D→P→G and G→D→R→P→G. Drone C was used in the G→Q→N→G and G→N→P→G.

6 Evaluation of models

6.1 Comprehensive evaluation model

Because the data is nondimensionalized, and the optimal solution is calculated by the method of exhaustion, the amount of data is huge. Now extract 5 nondimendionalized data as reference to conduct the sensitivity analysis.

6.2 Sensitivity analysis for the performance function

Table 9: Model I.

	s	t	e	Adapt
$The original data$	0.95	0.85	0.84	0.865

Reduce the value of s step by step, remain unchanged for the other data, get the following cart:

Table 10: the sensitivity analysis for s

	Changes in Adapt
$s - 0.1$	-0.02
$s - 0.2$	-0.04
$s - 0.3$	-0.06

It can be known by analyzing the data that when the change rate for s is 10.5%, the influence rate for the adapt value is 2.1 dollors, so the sensitivity is relatively worse.

Reduce the value of t step by step, remain unchanged for the other data, get the following cart:

Table 11: the sensitivity analysis for t

	Changes in Adapt
$t - 0.1$	-0.02
$t - 0.2$	-0.04
$t - 0.3$	-0.06

It can be known by analyzing the data that when the change rate for s is 11.8%, the influence rate for the adapt value is 2.3 dollors, so the sensitivity is relatively worse.

Table 12: the sensitivity analysis for e

	Changes in Adapt
$e - 0.1$	-0.03
$e - 0.2$	-0.06
$e - 0.3$	-0.09

It can be known by analyzing the data that when the change rate for s is 11.9%, the influence rate for the adapt value is 3.6 dollors, so the sensitivity is relatively better.

Model II Because the optimal solution is also calculated by the method of exhaustion, so in the same way, list one case to do the sensitivity analysis, extract the data as follows:

Table 13: $A - i$

Coordinate point	1	2	3	4
$Quantity$	2	3	2	5

Table 14: C_i

Coordinate point	1	2	3	4
x	35	-3	-7	-16
y	33	22	44	40

Table 15: R_i

Coordinate point	1	2	3	4
R_i	1/6	1/4	1/6	5/12

Now,S = 45.51

I do the sensitivity analysis for $A_i)$ The value of Coordinate point minus 1 successively; When the value of Coordinate point is 4, s=42.31; When the value of Coordinate point is 3, s=39.62; When the value of Coordinate point is 2, s=41.31; As the quantity of coordinate point4 is reduced by 20%, the influence for the S value decrease firstly and then increase. By analyzing the model, when the value of coordinate point4 is 3, the S value is the lowest, so it's the optimal scheme. When the average change rate for the S value is 7.03%, the sensitivity is very good.

II do the sensitivity analysis for C_i Reduce the corresponding x, y value for Coordinate to 2826.4,2119.8,1413.2; When the value of Coordinate point1 is (28, 26.4), s=43.52; When the value of Coordinate point1 is (21, 19.8), s=42.04; When the value of Coordinate point1 is (14, 13.2), s=41.46; When the Coordinate value of Coordinate point1 is reduced by 20% successively, the appropriate average change rate for s is 2.97%

II do the sensitivity analysis for R_i Reduce R value for Coordinate point 4 by 20% successively When the R value for Coordinate point 4 is 4/12, s=42.23 When the R value for Coordinate point 4 is 3/12, s=38.94 When the R value for Coordinate point 4 is 2/12, s=35.65 When the R value for Coordinate point 4 is reduced by 20% successively, the appropriate average change rate for s is 7.23%.

7 Strengths and Weaknesses

Here, some strengths and weaknesses are presented below.

7.1 Strengths

Innovative

- Unify the dimensions with many factors with different order of magnitudes, obtain the intuitionistic evaluate standard through linear combination, which is very general. Each score in the scheme can be obtained by enumeration method, and the highest-score scheme can be screened, which is of high reliability. The present of multi-cargo load principle simplifies the calculation to a great extent.

Rational

- The solution is fairly reliable because there are two models to be used to be close to the best solution from two different direction

- Model II combines the 3 factors and takes overall consideration, which is comprehensive. The way to deal with the rate that takes to transport in model II has innovativeness. The only optimal solution is obtained by combining the 6 optimal solutions in model II and the single optimal solution in model I, which is very innovative.

Easy understood

- The simple and understandable the optimal route model is adopted to the basic model for the the optimal path.

7.2 Weaknesses

- Because of the classification problems, there are 6 optimal solutions in model II, it's a little bit difficult to choose a better solution among these solutions.
- The data volume is too large in this article; the efficiency of calculation is still very low even if many principles are adopted to simplify it.

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Memo

Investigation Report of Optimal mode of medical material transportation and road reconnaissance

The sender: MCM Team
The recipient: The Chief Operating Officer of the HELP, Inc
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Puerto Rico needs two containers to make up this DroneGo disaster response system.

The problems of assemble

For containers assembly problem, container I needs 6 drone B, 9 drone C and Med1, Med2, Med3, in a ratio of 4:1:4; container II needs 5 drone B, 8 drone D, 8 drone F and Med1, Med2,in a ratio of 3:1. For the choice of drone problems, we think it over before we get the results which is based on comprehensive evaluation of performance. We know that drone B has the best reconnaissance capability and good transportation capability and so on. For the drug supply problems, the specific number of days of continuous supply depends on the number of days your company clears major roadway obstacles (i.e. the day before the arrival of the rescue team in your esteemed company). Because the concrete data is not known, we only giving you 30 days' supply of the drug (the actual assembly depends on the actual situation. Because a container full of drugs can satisfy the whole Puerto Rico's quantity demanded for more than a year). For the pathfinding problems, the road exploration mission will end on the second day after the completion of the system layout. So , the final data can reach your company in time to enable immediate deployment of the cleanup task.

The problems of drop According to our precise calculation, cargo container I will be dropped into the position with longitude -66.97 degrees, northern latitude 18.33 degrees,cargo container II will be dropped into the position with longitude -66.97 degrees, northern latitude 18.37 degrees. The 2 positions can optimize the ability to transport and reconnoiter, so they are the optimal known solutions.

The problems of system operation

For each drone in the disaster response subsystem, the assemblies, the transport routes, the running schedule all have different demands. However, the complex assemblies, transport routes and the running schedule are mainly concentrated on the first 3 days (a drone will conduct both medical supply delivery and video reconnaissance of road networks), and the task of reconnoitering roads can finish on the third day. From the fourth day, the drones will only transport. It tremendously speeds up the rescue forces' arrival.

Suggestions

If your esteemed company can provide us with the data of the area the drones explore and the enthesis coordinates and length information of the main roads, we can provide a more precise map for the drones' reconnaissance route, even the function for the drones' flying route to give more effectively and precisely transport plan and explore plan.

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