

# Study of Unmanned Aerial Vehicle Scheduling Disaster Rescue System

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**Abstract.** This paper designs to develop a transportable disaster response system named "DroneGo" through the deployment of drones, medical packages and containers to solve the problem of medical relief in the face of hurricane in Puerto Rico. Firstly, this paper aims to carry as many medical packages as possible. With the requirements of medical packages in disaster areas and the upper limit of the volume of ISO containers as constraints, adorned fleet and a set of medical packages meeting the requirements of Puerto Rico's hurricane scenario are obtained by using the integer programming model. Secondly, two optimal locations for the DroneGo disaster response system container were determined using the non-linear optimization, so as to be able to perform medical supply delivery and video reconnaissance on the road network. Finally, simulated annealing algorithm and shortest path algorithm are adopted to plan the delivery route, schedule and flight plan of the drone. Based on the analysis of the above problems, this paper establishes a viable "DroneGo" transportable disaster response system. Furthermore, in case of future hurricane disasters exceeding the scale of existing disasters, the system established in this paper can still meet the medical relief needs brought by disasters after some minor adjustments.

**Keywords:** Integer programming, Nonlinear unconstrained extremum model, DroneGo disaster response system, Shortest path algorithm.

## 1. Introduction

### 1.1 Background

Chronic disease patients are increasingly turning to hospitals and temporary shelters for treatment, so demand for medical services in Puerto Rico continues to surge. In 2017, Puerto Rico in the United States was hit by the worst hurricane on record. The island was badly damaged and more than 2,900 people died as a result of the storm. The combined destructive power of the hurricane's storm surge and waves wreaked havoc on buildings, homes and roads in Puerto Rico.

The storm, accompanied by strong winds and heavy rain, destroyed 80 percent of Puerto Rico's power poles and all transmission lines, leaving the island largely without power. In addition, the storm damaged or destroyed much of the island's mobile communications network. Most of the island was without power for months, in some cases longer. Widespread flooding has blocked and damaged many roads on the island, making it impossible for emergency vehicles on the ground to plan and navigate their routes. The extent of the damage in Puerto Rico remains unclear for some time, with dozens of areas quarantined and no communications. The need for medical supplies, life-saving equipment and treatment has strained relief operations at health clinics, hospital emergency rooms and non-governmental organizations. Chronic disease patients are increasingly turning to hospitals and temporary shelters for treatment, so demand for medical services in Puerto Rico continues to surge.

### 1.2 Restatement of the Problem

The non government organizations HELP.inc is trying to help the government by designing a transportable disaster response system called DroneGo. DroneGo will use rotorcraft drones to deliver prepackaged medical supplies and provide high-resolution aerial video reconnaissance.

DroneGo prepackaged medical supplies are called med kits and come in three varieties: MED1, MED2 and MED3. The drone will carry the medical packages in the drone's cargo bay to a designated

location in the attachment. The drone's video function will provide high resolution video of the damaged and available transportation network to help American airlines' command and control center with ground route planning. Help.inc will use dry cargo containers from the international standard organization (ISO) to quickly deliver a complete drone disaster response system to specific disaster areas.

To develop a drone disaster response system to support hurricane disaster scenarios in Puerto Rico, the following questions were asked:

A. Recommend A fleet of drones and A medical kit for help.inc. The DroneGo disaster response system needs to meet the requirements of the Puerto Rico hurricane scenario by designing packaging configurations for up to three ISO cargo containers to ship the system to Puerto Rico.

## 2. Assumptions and Notations

### 2.1 Assumptions

- (1) Assume that the same type of drone carries the same type and number of medical kits.
- (2) Does not consider the bearing capacity of goods in ISO containers.
- (3) Because the affected area cannot be docked due to a hurricane, it is assumed that the affected area cannot be used as a disaster relief center, that is, the container cannot be placed.
- (4) In order to save disaster relief resources, it is assumed that as few ISO containers as possible are used, and fewer locations are used to place containers.
- (5) Since the size of the ISO container is much larger than that of the cargo contained therein, and the cargo contained therein is a regular rectangular parallelepiped, it is assumed that the loading mode of the container is not considered, and only whether the remaining volume can carry the remaining cargo is considered.
- (6) Assuming that the selected aircraft is basically available, the ISO container can carry as many medical packages as possible.

### 2.2 Notations

- $x_i$  :The number of i-type medical bags carried
- $y_i$  :The number of type I aircraft carried
- $n$  :Types of medical kits
- $m$  :Types of drones
- $V_i$  :The volume of a shipping container carrying type I aircraft
- $v_i$  :The volume of type i medical kits
- $V$  :The volume of the international standard organization (ISO)
- $M$  :Total number of drones
- $m_i$  :Maximum capacity of each drone
- $n_i$  :The daily requirement for drug i

## 3. Analysis of the Problem

Question A requires the selection of a drone fleet and a medical kit for medical use for the detection of supply and road conditions in the disaster area. Since the problem does not limit the funds, and the medical kit is used for long-term disaster area supply. It is required that the ISO container can carry as many medical kits as possible when the selected aircraft is basically available. Through the integer programming in operational research, aiming at carrying as many medical packages as possible, the problem A was solved under the constraints of the requirements for medical packages in disaster areas and the volume upper limit of ISO containers.

#### 4. Establishment and Solution of the Model

Integer programming model is selected for problem A.

Taking carrying as many medical bags as possible as the objective function, the following is obtained:

$$\max Z = \sum_{i=1}^n x_i \quad (1)$$

Make the following constraints:

First, the volume of the ship container and the total volume of the medical package loaded with the drone are smaller than the volume of the ISO container, which can be obtained as follows:

$$\sum_{i=1}^m V_i \times y_i + \sum_{i=1}^n v_i \times x_i \leq V \quad (2)$$

Secondly, the total number of drones shall not exceed M, and the number of each type of aircraft shall not exceed  $m_i$ , as follows:

$$x_i \geq 0, y_i \geq 0 (x_i, y_i \in \mathbb{Z}) \quad (3)$$

$$\max Z = \sum_{i=1}^n x_i \quad (4)$$

$$s.t. \left\{ \begin{array}{l} \sum_{i=1}^m V_i \times y_i + \sum_{i=1}^n v_i \times x_i \leq V, \\ \sum_{i=1}^M y_i \leq M, \\ Y_i \leq m_i, \\ \frac{x_1}{n_1} = \frac{x_2}{n_2} = \dots = \frac{x_n}{n_n}, \\ x_i \geq 0, \\ y_i \geq 0, \\ x_i, y_i \in \mathbb{Z} \end{array} \right. \quad (5)$$

Lingo is used for programming solution, and the results are shown in the table:

Table 1. Number of MED

MED	COUNT
1	1155
2	330
3	660

Table 2. Number of drones

<b>DRONE</b>	<b>COUNT</b>
<b>A</b>	<b>3</b>
<b>B</b>	<b>3</b>
<b>C</b>	<b>3</b>
<b>D</b>	<b>0</b>
<b>E</b>	<b>0</b>
<b>F</b>	<b>2</b>
<b>G</b>	<b>1</b>
<b>H</b>	<b>0</b>

Therefore, the results in the above table are obtained on the premise that the ISO container can carry as many medical packages as possible.

## 5. Conclusion

### 5.1 Conclusion on Question A

Lingo is used for programming solution and the results are shown in the table

Table 3. Number of MED

<b>MED</b>	<b>COUNT</b>
<b>1</b>	<b>1155</b>
<b>2</b>	<b>330</b>
<b>3</b>	<b>660</b>

Table 4. Number of drones

<b>DRONE</b>	<b>COUNT</b>
<b>A</b>	<b>3</b>
<b>B</b>	<b>3</b>
<b>C</b>	<b>3</b>
<b>D</b>	<b>0</b>
<b>E</b>	<b>0</b>
<b>F</b>	<b>2</b>
<b>G</b>	<b>1</b>
<b>H</b>	<b>0</b>

Therefore, the results in the above table are obtained on the premise that the ISO container can carry as many medical packages as possible.

## 6. Evaluate of the Model

### 6.1 Applicability of the Model

The disaster relief system has a high applicability, but some compromises are needed in some cases to prevent the system from being paralyzed and unable to be used. Relevant problem analysis will be given below:

The system can cope with situations such as more disaster relief sites, greater demand for medical kits, and more complex road conditions. If the number of sites increases, the response is simply to change the grouping of disaster areas and replan flight paths. If the demand for medical kits increases, it can be solved by increasing the number of aircraft carried and the utilization rate of containers. However, the complexity of road conditions does not affect the search for the shortest path, the computer can quickly find the best way to rescue the hundreds of roads.

### 6.2 Strengths

(1) In the establishment of the model, reasonable planning directions (such as carrying more medical bags, making short-range drone convenient for reconnaissance, etc.) were selected in combination with the actual situation, and relatively optimized results were obtained.

(2) Divide and conquer a complete problem to get a clear solution.

### 6.3 Weaknesses

(1) Some data (such as position coordinates, distance, etc.) are approximately processed, resulting in certain errors in the results.

(2) Given too few restrictions, the establishment of the model considered the one-sided optimality, but could not give a more comprehensive consideration.

(3) There are too many changes in the actual situation, and some unnecessary factors are neglected in the process of model establishment, in order to get a more ideal model.

## References

- [1]. Shoukui Si, Zhaoliang Sun. Mathematical modeling algorithm and application (second edition). Beijing: national defense industry press, 2015.
- [2]. Dingyu Xue, Yangquan Chen. Solving higher applied mathematical problems with MATLAB (third edition) [M]. Beijing: tsinghua university press, 2013.
- [3]. GuiyuanYang, Jiaming Zhu. Evaluation and analysis of excellent papers in mathematical modeling contest [M]. Hefei: university of science and technology of China press, 2013.
- [4]. Jinxing Xie, Yi Xue. Optimization modeling and LINDO/LINGO software. Beijing: tsinghua university press, 2005.
- [5]. Fogel D B. An introduction to simulated evolutionary optimization. IEEE Transaction Neural Network, 1994, (1): 3-14.