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summary sheet

Contents

Abstract

T he severe hurricane hit Puerto Rico affected millions of heart. Designing a transportable disaster response system called “DroneGo.” is an excellent idea to solve such problems. We used mathematical modeling methods to study the issues involved in packing, site selection, configuration, and flight planning.

F or the delivery of the system ”DroneGo.” to Puerto Rico, we simulated the idea that people always try to ensure a relatively ”flat” when packing, and designed a 0 1 programming model with the goal of maximizing the overall space utilization of the container. Intelligent heuristic

Key words: 3D container load, 0 1 programming,

1 Introduction

1.1 Background

In 2017, the worst hurricane to ever hit the United States territory of Puerto Rico left the island with severe damage and caused over 2900 fatalities.

At present, drones have been widely used in many fields, including the film and television industry, traffic supervision, accident relief, etc. As long as the corresponding rules and

1.2 Restatement of the problem

There are some standard dry cargo contain er and three different medical packages referred to as MED1,MED2, and MED3.

1. Design each container configuration using a maximum of three containers.
2. Determining the best location for three cargo containers to enable medical supply delivery and video reconnaissance of the road network s.

2 Analysis of Specific Issues

2.1 Question A

This questions asked us to suggest a Dronego disaster response system for a fleet of drones and a medical kit to help the company.

2.2 Question B

Problem B requires us to determine the optimal location for 1 to 3 cargo container s. In this regard, we first perform performance analysis on various types of drones ,

3 Assumptions & Symbols

3.1 Assumptions

1. In the process of drone transportation, the influence of wind direction and wind direction on it is not considered;
2. Regardless of the impact of altitude;

3. Ignore the impact of drones slowing down flight speed due to increased loa

3.2 Symbols

Table 1: symbols

p	Space occupancy ratio		
$(l_{i_1}, w_{i_1}, h_{i_1})$	Medical package size		$i_1 = 1, 2, \ldots, m$
$(L_{i_2}, w_{i_2}, H_{i_2})$	Drone Cargo Bay size	in	$\tilde{l}_2 = 1, 2, \ldots, n$

4 Models

4.1 Analysis and Solving of Question A

Question A requires us to design a packaging configuration for up to three standard containers and ship them to Puerto Rico for medical supplies.

4.1.1 Model Establishment

Because the hurricane has caused severe disasters everywhere and the demand for medical kits is high, we should try our best to meet the demand for medical kits. Therefore

The specific planning process is as follows:

1. Objective function:

   First, we introduce the 0-1 variable to represent the packing selection.

   Then, the maximum comprehensive space occupation ratio of medical package to Cargo compartment,

$$\text{Max}\,\rho = \alpha \times \sum_{i_2=1}^{n}\sum_{i_1=1}^{m}\frac{l_{i_1}w_{i_1}h_{i_1}x_{i_1i_2}}{L_{i_2}W_{i_2}H_{i_2}} + (1-\alpha)\times\left[\sum_{i_4=1}^{n}\sum_{i_2=1}^{n}\frac{L_{i_2}W_{i_2}H_{i_2}y_{i_2i_4}}{A_{i_4}B_{i_4}C_{i_4}} + \sum_{i_4=1}^{3}\sum_{i_3=1}^{q}\frac{a_{i_3}b_{i_3}c_{i_3}z_{i_3i_4}}{A_{i_4}B_{i_4}C_{i_4}}\right] \tag{1}$$

2. Constraints After getting the objective function, we analyze the constraints of the objective function.

   (a) Quantity conservation constraints Suppose the total number of medical packages placed is m, the total number of Drone Cargo Bay used is n and the number of shipping containers is q.

$$\sum_{i_2=1}^{n}\sum_{i_1=1}^{m} x_{i_1i_2} = \sum_{j=1}^{3} m_j = m \tag{2}$$

   In the same way, we will ensure the conservation of the quantity of cargo compartments and containers before and after placement:

   (b) Basic boxing constraints In solving the three-dimensional packing problem, the condition to be satisfied is that after the item is placed in the box, t

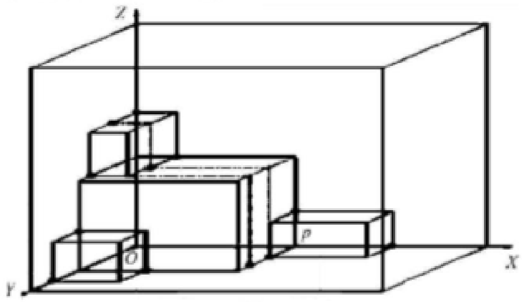

Figure 1: Coordinate system diagram

$$
s.t.\begin{cases}
\sum_{i_2=1}^{n}\sum_{i_1=1}^{m} x_{i_1 i_2} = \sum_{j=1}^{3} m_j = m\ ;\ \sum_{i_4=1}^{3}\sum_{i_2=1}^{n} y_{i_2 i_4} = \sum_{k=1}^{2} n_k = n; \sum_{i_4=1}^{3}\sum_{i_3=1}^{q} z_{i_3 i_4} = \sum_{t=1}^{8} q_t = q \\
0 \le Min(l_{i_1}, w_{i_1}, h_{i_1}) \le Max(L_{i_2}, W_{i_2}, H_{i_2}) \\
0 \le Min(L_{i_2}, W_{i_2}, H_{i_2}) \le Max(A_{i_4}, B_{i_4}, C_{i_4}) \\
0 \le Min(a_{i_3}, b_{i_3}, c_{i_3}) \le Max(A_{i_4}, B_{i_4}, C_{i_4}) \\
x_p + x_{i_1 i_2} \times (l_{i_1}^x l_{i_1} + w_{i_1}^x w_{i_1} + h_{i_1}^x h_{i_1}) \le L_{i_2} \\
y_p + x_{i_1 i_2} \times (l_{i_1}^y l_{i_1} + w_{i_1}^y w_{i_1} + h_{i_1}^y h_{i_1}) \le W_{i_2} \\
z_p + x_{i_1 i_2} \times (l_{i_1}^z l_{i_1} + w_{i_1}^z w_{i_1} + h_{i_1}^z h_{i_1}) \le H_{i_2} \\
x_p + y_{i_2 i_4} \times (L_{i_3}^x L_{i_3} + W_{i_3}^x W_{i_3} + H_{i_3}^x H_{i_3}) \le A_{i_4} \\
y_p + y_{i_2 i_4} \times (L_{i_3}^y L_{i_3} + W_{i_3}^y W_{i_3} + H_{i_3}^y H_{i_3}) \le B_{i_4} \\
z_p + y_{i_2 i_4} \times (L_{i_3}^z L_{i_3} + W_{i_3}^z W_{i_3} + H_{i_3}^z H_{i_3}) \le C_{i_4} \\
x_p + z_{i_3 i_4} \times (a_{i_3}^x a_{i_3} + b_{i_3}^x b_{i_3} + c_{i_3}^x c_{i_3}) \le A_{i_4} \\
y_p + z_{i_3 i_4} \times (a_{i_3}^y a_{i_3} + b_{i_3}^y b_{i_3} + c_{i_3}^y c_{i_3}) \le B_{i_4} \\
z_p + z_{i_3 i_4} \times (a_{i_3}^z a_{i_3} + b_{i_3}^z b_{i_3} + c_{i_3}^z c_{i_3}) \le C_{i_4} \\
l_{i_1}^x + w_{i_1}^x + h_{i_1}^x = 1\ ;\ l_{i_1}^y + w_{i_1}^y + h_{i_1}^y = 1?\ l_{i_1}^z + w_{i_1}^z + h_{i_1}^z = 1 \\
L_{i_2}^x + W_{i_2}^x + H_{i_2}^x = 1\ ;\ L_{i_2}^y + W_{i_2}^y + H_{i_2}^y = 1\ ;\ L_{i_2}^z + W_{i_2}^z + H_{i_2}^z = 1 \\
a_{i_3}^x + b_{i_3}^x + c_{i_3}^x = 1\ ;\ a_{i_3}^y + b_{i_3}^y + c_{i_3}^y = 1\ ;\ a_{i_3}^z + b_{i_3}^z + c_{i_3}^z = 1 \\
x_{i_1 i_2}, y_{i_2 i_3}, z_{i_3 i_4}, l_{i_1}^x, w_{i_1}^x, h_{i_1}^x, \cdots, a_{i_3}^z, b_{i_3}^z, c_{i_3}^z \in \{0,1\}
\end{cases}
$$

Figure 2:

To ensure that it does not exceed the size range of the large box when place, We add 12 constraints, see the model.

According to the above analysis, the 3D packing model is as follows:

$$
\operatorname{Max} \rho = \alpha \times \sum_{i_2=1}^{n}\sum_{i_1=1}^{m} \frac{l_i w_{i_1} h_{i_1} x_{i_1 i_2}}{L_{i_2} W_{i_2} H_{i_2}} + \beta \times \left[\sum_{i_4=1}^{3}\sum_{i_2=1}^{n} \frac{L_{i_2} W_{i_2} H_{i_2} y_{i_2 i_4}}{A_{i_4} B_{i_4} C_{i_4}} + \sum_{i_4=1}^{3}\sum_{i_3=1}^{q} \frac{a_{i_3} b_{i_3} c_{i_3} z_{i_3 i_4}}{A_4 B_{i_4} C_{i_4}} \right]
$$

4.1.2 Model Establishment

Because the hurricane has caused severe disasters everywhere and the demand for medical kits is high,

$$
\sum_{i_4=1}^{3}\sum_{i_3=1}^{q} z_{i_3 i_4} = \sum_{i=1}^{8} q_t = q \tag{3}
$$

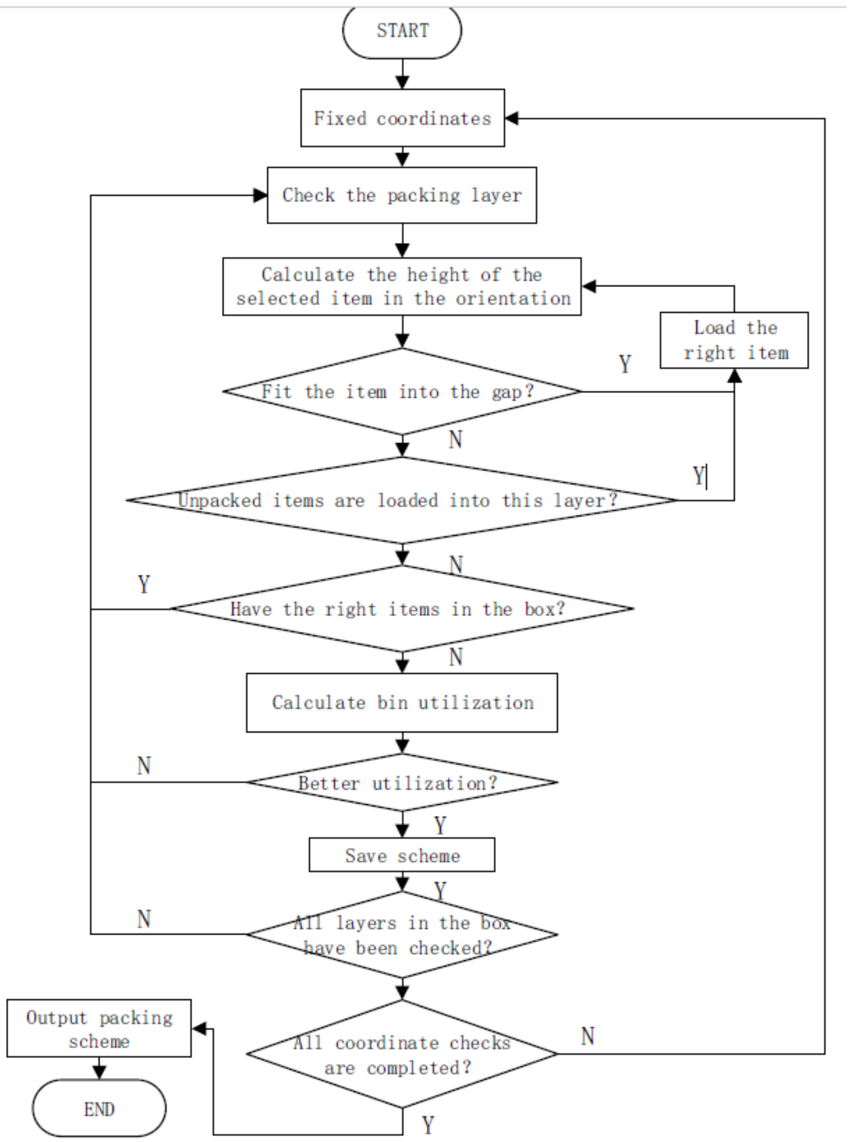

Figure 3: Intelligent Heuristic Approach

$$\sum_{i_4=1}^{3}\sum_{i_3=1}^{q} z_{i_3 i_4} = \sum_{i=1}^{8} q_{\mathrm{t}} = q \tag{4}$$

$$0 \leq \operatorname{Min}\left(l_{i_1}, w_{i_1}, h_{i_1}\right) \leq \operatorname{Max}\left(L_{i_2}, W_{i_2}, H_{i_2}\right) \tag{5}$$

$$0 \leq \operatorname{Min}\left(L_{i_2}, W_{i_2}, H_{i_2}\right) \leq \operatorname{Max}\left(A_{i_4}, B_{i_4}, C_{i_4}\right) \tag{6}$$

Cargo Bay compartment along the x-axis $l_{i_1}^{y}, w_{i_1}^{y}, h_{i_1}^{y}, l_{i_1}^{z}, w_{i_1}^{z}, h_{i_1}^{z}, L_{i_3}^{x}, W_{i_3}^{x}, H_{i_3}^{x}, L_{i_3}^{y}, W_{i_3}^{y}$

1. First, we use genetic algorithms to write matlab programs See Appendix 6 for detailed procedures. to find out the combination of goods packing

   Step 1 encodes and initializes the solution space (set the upper and lower bounds of the total number of Drone Cargo Bay);

   Step 2 initialize population

$$D = \begin{array}{cc} & \begin{matrix} A & B & C & D & E \end{matrix} \\ \begin{matrix} \mathit{Caribbean}\text{Medical Center A} \\ \text{Hospital HIMB A} \\ \text{Hospital Pavia Santurce C} \\ \text{Puerto Rico Children's Hospital D} \\ \text{Hospital Pavia Arecibo E} \end{matrix} & \begin{bmatrix} 0 & & & & \\ 41.99 & 0 & & & \\ 46.03 & 24.85 & 0 & & \\ 54.44 & 24.30 & 10.50 & 0 & \\ 115.14 & 79.03 & 69.77 & 60.70 & 0 \end{bmatrix} \end{array} \tag{7}$$

$$\begin{aligned} x^4 &= y \\ x^6 &= y \end{aligned} \tag{8}$$

$$\text{min} \quad \text{mum} = \sum_{k=1}^{3} \sum_{i=1}^{7} x_{ki} \tag{9}$$

$$T_1 \leq \frac{f_B}{2}, T_2 \leq \frac{f_B}{2}, T_3 \leq \frac{f_F}{2}, T_4 \leq \frac{f_B}{2}, T_5 \leq \frac{f_B}{2} \tag{10}$$