Medicine Distribution By Using The Method Of The Center Of Gravity

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Abstract: Under the condition of using the least time, we hope to minimize the cost. As is known to all, the shorter distance is, the less money we spend. Thus, the problem of cost is transformed into the problem of distance. We choose four addresses as supply points and view the amount of medicine which they need as their weight. According to the method of the center of gravity, we can get the center of gravity that is the best distribution center.

Introduction

Ebola virus disease (EVD), formerly known as Ebola hemorrhagic fever, is a severe, often fatal illness in humans. The virus is transmitted to people from wild animals and spreads in the human population through human-to-human transmission. The average EVD case fatality rate is around 50%. Case fatality rates have varied from 25% to 90% in past outbreaks.The first EVD outbreaks occurred in remote villages in Central Africa, near tropical rainforests, but the most recent outbreak in West Africa has involved major urban as well as rural areas.In this condition,the medicine is necessary and how to choose the medicine distribution is also important.

Model of the center of gravity

Model Overview

Due to the medicine for Ebola drug in urgent need, in this paper, we adopt aircraft for transport. Under the condition of using the least time, make to minimize the cost of money. Because of the relation between cost and distance, low cost principle is simplified to the problem of the shortest distance. Various methods are applied to get the shortest straight distance between distribution center and supply center, as a reference to deciding the distribution center.

For the first, we search for 4 supply center, in this paper, we choose the capitals of the countries, because of its more developed economy and more convenient transport .Then, we calculate their three-dimensional coordinates according to their latitude and longitude.

In order to minimize the distance between distribution center and supply center, we use the center of gravity method and the principle of moment to get the coordinates of the center of gravity. By calculating, we obtain the latitude and longitude of the distribution center.

The solution to the three-dimensional coordinates

We assume that the center of the earth for the origin of the Cartesian coordinates, center and 0 longitude points on the equator as the X axis, center and east longitude 90 degree on the equator as the Y axis, center and the point of north pole as the Z axis, so the relationship between the ground point of Cartesian coordinates and the latitude and longitude lines is：

$$\begin{aligned} x &= r \times \cos\alpha \times \cos\beta \\ y &= r \times \cos\alpha \times \sin\beta \\ z &= r \times \sin\alpha \end{aligned} \qquad (1)$$

Where:

r is the radius of the Earth, which is 6400 km.

α is the latitude, north latitude is positive and south latitude is negative.

β is the longitude, east longitude is positive and west longitude is negative.

Choose distribution addresses

We choose Conakry which is the capital of Guinea, Monrovia which is the capital of Liberia, Freetown which is the capital of Sierra Leone and Abuja which is the capital of Nigeria for distribution addresses.

Table 1

the latitude and longitude of different countries

Country	Conakry	Monrovia	Freetown	Abuja
Latitude and longitude	13°43′W,9°30′ N	10°46′W,6°2′N	13°17′W,8°3′N	7°11′W,9°12′N

Therefore, the three-dimensional Cartesian coordinates of these addresses are gotten. Their three-dimensional Cartesian coordinates are showed in **Table 2**

Table 2

Three-dimensional Cartesian coordinates

Conakry	(6132.1, -1497.1, 1056.3)	Monrovia	(6252.5, -1189.3, 672,3)
Freetown	(6167.5, -1455.7, 896.2)	Abuja	(6268.1, 789.6, 1023.2)

The method of the center of gravity

There are 4 supply centers, spread in different coordinates (x_j, y_j, z_j) .Now, we assuming that the distribution center is set at (x_0, y_0, z_0) . H is the total cost for transportation can be expressed that:

$$H = \sum_{j=1}^{4} a_j w_j d_j \, (j = 1,2,3,4) \qquad (2)$$

Where:

a_j is the cost for transporting medicine from distribution center to supply center j per weight and per distance.(j=1,representing Conakry's=2,representing Monrovia's=3, representing Freetown's=3,representing Abuja)

w_j is the amount of medicine which is transported to supply center j .(according to the data of the WHO, $w_1 = 495, w_2 = 516, w_3 = 691, w_4 = 9$)

d_j is the distance between distribution center and supply center j .

d_j can be expressed that:

$$d_j = \sqrt{(x_0 - x_j)^2 + (y_0 - y_j)^2 + (z_0 - z_j)^2} \, (j = 1,2,3,4)$$

The least cost should be guaranteed when choosing the distribution center, that is, H is the minimum.

Order: $g_j = a_j w_j \, (j = 1,2,3,4)$

So, equation (11) can be expressed that: $H = \sum_{j=1}^{4} g_j d_j \, (j = 1,2,3,4)$.

According to the method of the center of gravity, we view the supply centers as particles which have weight. g_j is the equivalent weight of each particle, the center of gravity is the point that is the nearest to each particle. In this way, seeking the distribution center is transformed into searching coordinates of the center of gravity. So, it is simple to simulate coordinates of the center of gravity.

Assume G as the weight of the center of gravity, $G = \sum_{j=1}^{4} g_j \, (j = 1,2,3,4)$.

According to the characteristics of the center of gravity, it can be known that the moment of equivalent weight at the center of gravity to the origin of the xyz is equal to the moment of the particles to the original point in the xyz. Physical equation is expressed as:

$$Gd_0 = \sum_{j=1}^{4} g_j d_j = \sum_{j=1}^{4} a_j w_j d_j \, (j = 1,2,3,4) \tag{3}$$

Resolve the moment produced by the center of gravity along x axis, y axis, and z axis, which respectively, equal to the moment that is resolved along x axis, y axis, and z axis of the particles. These three equations are just as following:

$$\begin{aligned} Gx_0 &= \sum_{j=1}^{4} g_j x_j = \sum_{j=1}^{4} a_j w_j x_j \, (j = 1,2,3,4) \\ Gy_0 &= \sum_{j=1}^{4} g_j y_j = \sum_{j=1}^{4} a_j w_j y_j \, (j = 1,2,3,4) \\ Gz_0 &= \sum_{j=1}^{4} g_j z_j = \sum_{j=1}^{4} a_j w_j z_j \, (j = 1,2,3,4) \end{aligned} \tag{4}$$

Finally, we get coordinates of the center of gravity:

$$\begin{aligned} x_0 &= \sum_{j=1}^{4} a_j w_j x_j \Big/ \sum_{j=1}^{4} a_j w_j \quad (j = 1,2,3,4) \\ y_0 &= \sum_{j=1}^{4} a_j w_j y_j \Big/ \sum_{j=1}^{4} a_j w_j \quad (j = 1,2,3,4) \\ z_0 &= \sum_{j=1}^{4} a_j w_j z_j \Big/ \sum_{j=1}^{4} a_j w_j \quad (j = 1,2,3,4) \end{aligned} \tag{5}$$

So,(6183.4 ,-1375.5 , 875.7) is the coordinates of the center of gravity which is thought as the distribution center.

By simulating, the longitude and latitude of distribution center can be gotten. It is(7.86°N,12.75°)

Figure 1 the center of transport

Conclusion

We determine the distribution center by using the method of the center of gravity and calculate the results with a large amount of goods. Similarly, the distribution centers can be obtained according to the method with fewer amounts of goods. Then, we move and average the distribution centers based on many kinds of goods to get the best distribution center. What is said above can be a basis for capitals to supply medicine to other cities.

References

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