|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | For office use only | | | T1 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | T2 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | T3 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | T4 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | |  | | --- | | Team Control Number **1901387** | |  | | Problem Chosen **B** | | |  |  | | --- | --- | | For office use only | | | F1 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | F2 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | F3 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | F4 | \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | |
| **2019 MCM/ICM Summary Sheet** | | |

A Dynamic Model of Language Evolution

Summary

In order to predict the number of L1 and L2, we looked at several types of data: the number of L1 and L2 in the first category. The second category: the number of countries over the years and the use of languages. The third Category: Gross domestic product, GDP per capita, natural index of each country, assessment of national education level, evaluation of national Policy index, etc.

In order to find the relationship between the data, we first carried out the cluster analysis, and then we had the linear regression analysis respectively. We believe that the population and language use are the main factors affecting the number of L1, while the number of L2 is related to GDP, natural index and language area. So we decided to use the logistic population forecast model to predict the number of L1 in terms of the data characteristics, and finally our results show that there are several languages L1 in the next 50 years (this is the predicted result). For L2 we think that diffusion equations in fluid mechanics can simulate the growth of L2 population, so we build our equations according to the Fick law. The number of L2 in the next 50 years is calculated.

In order to solve the problem of the office clearly, we have further processed the data. First we took advantage of the scoring queue to evaluate the situation of the language for the next 50 years, and finally confirmed that the offices we were going to set up should be located in the (results), and the language in the office would be the results. Of course, through the analysis we found that the results of the assessment in the last 20 years and the next 50 years there are differences. So we think that the future office may need to change. As for the need to set up six offices, we have interpolated the population data and calculated the slope of the points, because the lack of company data does not yield accurate benefit expectations, so we generally think that we need to handle six offices.

Keywords: cluster analysis, linear regression, population prediction, diffusion equation, scoring line method参考模板简要说明(Page6), 阅后务必删除…

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# 1 Introduction

## 1.1 Problem Background

In recent years, the deployment of medical drugs through airdrops has become more common and more widely used; it is because it is a precise method of calculating the speed, wind direction, wind speed, height and other factors of the drone. Very accurate air delivery.

Now HELP, Inc invites us to design a mobile disaster response system called "DroneGo" that not only provides high-resolution aerial video but also accurately delivers pre-packaged medical supplies. This is extremely important for areas hit by natural disasters.

## 1.2 Previous Research

Some magazines and websites that focus on language have collected the increase of users. We download database from Wor88ld Bank and other organizations. And take a look on many professional maginzes.

## 1.3 Breaking Down the Problem

After carefully analyzed the requirement from the Chief Operating Officer, we sort out five main sub-problems below to resolve in this paper:

1. Identification the parameters which have significant influence to the number of native speakers or non-native speakers.
2. Build reasonable models to predict how those parameters which influenced the number of native speaker growth over time.
3. Build reasonable models to predict how those parameters which influenced the number of non-native speaker growth over time.
4. Find out a logical model to estimates the increase(decrease) trend of the native speakers’ and non-native speakers’ number.
5. Design a strategy study for the company’s development.

To tackle the first problem, we choose some of the influential parameters referring the evaluation method to the language’s vitality from the Word's 10 Most Influential Languages written by George Weber. After that, we choose the more relative one by using the Hierarchical Clustering Method.

As for the second problem, considering all the influential parameters are consecutive and irrelevant, we use Logistic Regression to predict their growth trends

In a view of non-native speakers’ number increase(decrease) in dynamic process. We draw an analogy between the trend of non-native speakers’ number and the Fick’s Law to solve the third problem.

The fourth problem will be easily resolved through Regression Analysis with the data from the previous questions.

To deal with the touchy issue of operate the company. We use George Weber’s evaluation method to remark each language’s score.

# 2 Assumptions

* Since Puerto Rico’s geographical location is very small in the latitude and longitude of the Earth, it is assumed that Puerto Rico’s surface map on the globe is approximately flat.并且把地球看做一个球体。
* According to the background, there are four different types of packages from large to small: ISO container, shipping container, cargo bay, medical package. Their relationship is that the medical packages are installed in the cargo bay, and the cargo bay is installed in the shipping container. The entire emergency system is installed in the ISO container.
* Different types of medical packages need to be placed every day from five locations, so we can reasonably assume that all the medical packages required for each location are packed in a cargo bay. When the drone delivers these supplies, it only needs to be in the shipping container. A cargo bay is placed in one of the five locations specified.
* In order to simplify the calculations that follow, we will present the above five locations, Caribbean Medical Center, Hospital HIMA, Hospital Pavia Santurce, Puerto Rico Children's Hospital and Hospital Pavia Arecibo, a, b, c, d, e, respectively.

(这个不算是假设，可以写在参数表里面)。

* 无人机在传递医疗包的路线是直线，而且途中不允许降落到ISO cargo containers里面添加能量和医疗包，也就是说，无人机只有卸医疗包和完成传递任务返航回来才可以降落。
* 假设无人机负重时航程的减少和负重成正比。
* ISO cargo container和投放点不能重合，离投放点的最近距离要大于3km。
* 求解出来的ISO cargo container一定要在波多黎各的岛屿内部。
* 本论文使用的数据都是可靠的。

# 3 Nomenclature

表头，三列，第一列参数，第二列描述，第三列，单位（没有可写无，个这种单位也是无），最好是下面这种表格的形式

2005 年地方院校招生人数

|  |  |  |  |
| --- | --- | --- | --- |
| 学院 | 新生 | 毕业生 | 更改 |
|  | 本科生 |  |  |
| Cedar 大学 | 110 | 103 | +7 |
| Elm 学院 | 223 | 214 | +9 |
| Maple 高等专科院校 | 197 | 120 | +77 |
| Pine 学院 | 134 | 121 | +13 |
| Oak 研究所 | 202 | 210 | -8 |
|  | 研究生 |  |  |
| Cedar 大学 | 24 | 20 | +4 |
| Elm 学院 | 43 | 53 | -10 |
| Maple 高等专科院校 | 3 | 11 | -8 |
| Pine 学院 | 9 | 4 | +5 |
| Oak 研究所 | 53 | 52 | +1 |
| 总计 | 998 | 908 | 90 |

In this paper, we use the nomenclature in Figures and Formulas to describe our model.

|  |  |
| --- | --- |
| x | The Maximum of shipping container’s Length, Width, and Height |
| y | The Second largest value of shipping container’s Length, Width, and Height |
| z | The Minimum of shipping container’s Length, Width, and Height |
| q | The Maximum of cargo bay’s Length, Width, and Height |
| p | The Second largest value of cargo bay’s Length, Width, and Height |
| n | The Minimum of cargo bay’s Length, Width, and Height |
| N | The total number of shipping container can load cargo bay |

# 4 Part I: Two Models

## 4.1 Model I: Drone loading

### 4.1.1 Drone loading

要说一下在这个部分是不考虑距离的，只从空间和负重方面考虑。

Through the background, we can know that each of the four aircrafts A, B, C, and D can only carry one of two cargo bays. (After calculating A, B, C, D, E, F, the six aircrafts are calculated according to the volume space. The largest number of cargo bays that can be loaded is 27, 8, 4, 6, 1, 4 (Table 1, 2);

For aircraft, the shipping container's Length, Width, and Height are x, y, z respectively, from large to small; the cargo bay's demainsion from large to small are q, p, n.

If x>y>z, q>p>n, The main formula is

,,

With the data upper we can get the shipping container can load up to the total number of cargo bay is

|  |  |  |  |
| --- | --- | --- | --- |
|  | Length (in) | Width (in) | Height (in) |
| Cargo bay1 | 8 | 10 | 14 |
| Cargo bay2 | 24 | 20 | 20 |

**Table 1**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Length(in) | Width (in) | Height (in) | Weight(lbs.) | Bay type | Load |
| A | 45 | 45 | 25 | 35 | 1 | 27 |
| B | 30 | 30 | 22 | 8 | 1 | 8 |
| C | 60 | 50 | 30 | 14 | 2 | 4 |
| D | 25 | 20 | 25 | 11 | 1 | 6 |
| E | 25 | 20 | 27 | 15 | 2 | 1 |
| F | 40 | 40 | 25 | 22 | 2 | 4 |

**Table 2**: Load is the number of Cargo bays that can accommodate the corresponding kind

We will have the above five locations: Caribbean Medical Center, Hospital HIMA, Hospital Pavia Santurce, Puerto Rico Children's Hospital and Hospital Pavia Arecibo is represented by a, b, c, d, e, respectively. To determine whether it can be loaded into two types of cargo bays by calculating the sum of the storage space required for the different medical packages required by the five locations. We use this method to handle the following situations.

(1) Assuming that each aircraft can only be departed from one location and can only be in one ISO contioner; the ratio of the total load of the aircraft and the maximum number of cargo bays that can be loaded into the cargo bay is different from that required for the five types of locations. The type of aircraft loaded into the cargo bay is compared, and it can be concluded that the aircraft types that meet the five locations sent to a, b, c, d, e are shown in the following table (see Table 3).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Place | Requirement | Quantity | Weight(lbs.) | Ability Drone |
| a | MED 1  MED 3 | 1  1 | 5 | BCDEF |
| b | MED 1  MED 3 | 2  1 | 7 | CEF |
| c | MED 1  MED 2 | 1  1 | 4 | BCDEF |
| d | MED 1  MED 2  MED 3 | 2  1  2 | 12 | CEF |
| e | MED | 1 | 2 | ABCEF |

**Table 3:** The weight is the total weight of the medical packages and determines the type of drone that can be used.

(2) Assuming that the aircraft can deliver the required drugs to two different locations at a time; there are ten combinations of flight conditions, which are required to compare the total load of the aircraft and the maximum number of cans loaded into the cargo bay and ten combinations. Different medical packages are loaded into the type of cargo bay for comparison. It can be concluded that the aircraft types for ten conditions are as shown in the following table (see Table 4).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Place | Requirement | Quantity | Weight(lbs.) | Ability Drone |
| ab | Bay a+b | 5 | 12 | CF |
| ac | Bay a+c | 4 | 9 | CDF |
| ad | Bay a+d | 8 | 17 | F |
| ae | Bay a+e | 3 | 7 | BCDF |
| bc | Bay b+c | 5 | 11 | CF |
| bd | Bay b+d | 8 | 19 | F |
| be | Bay b+e | 4 | 9 | CF |
| cd | Bay c+d | 7 | 16 | F |
| ce | Bay c+e | 3 | 6 | BCDF |
| de | Bay d+e | 6 | 14 | CF |

**Table 4:** The type of drug contained in cargo bay is the same as in table3.

(3) Assuming that the aircraft can deliver the required drugs to three different locations at a time, there are a total of ten combinations of flight conditions, which are required to compare the total load of the aircraft and the maximum number and ten types that can be loaded into the cargo bay. Different medical packages are loaded into the type of cargo bay for comparison. It can be concluded that the aircraft types for ten conditions are as shown in the following table (see Table 5).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Place | Requirement | Quantity | Weight(lbs.) | Ability Drone |
| abc | Bay abc | 7 | 16 | F |
| abd | Bay abd | 10 | 24 | None |
| abe | Bay abe | 6 | 14 | CF |
| acd | Bay acd | 9 | 21 | F |
| ace | Bay ace | 5 | 11 | CDF |
| ade | Bay ade | 8 | 19 | F |
| bcd | Bay bcd | 10 | 23 | None |
| bce | Bay bce | 6 | 13 | F |
| bde | Bay bde | 9 | 19 | F |
| cde | Bay cde | 8 | 18 | F |

**Table 5:** The type of drug contained in cargo bay is the same as in table3.

(4) Assuming that the aircraft can deliver the required drugs to four different locations at a time, there are five combinations of flight conditions, which are required to compare the total load of the aircraft with the maximum number of five types that can be loaded into the cargo bay. Different medical packages are loaded into the type of cargo bay for comparison. It can be concluded that the five types of aircraft are as shown in the following table (see Table 7).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Place | Requirement | Quantity | Weight(lbs.) | Ability Drone |
| abcd | Bay abcd | 12 | 28 | None |
| abce | Bay abce | 8 | 18 | None |
| abde | Bay abde | 11 | 26 | None |
| acde | Bay acde | 10 | 23 | F |
| bcde | Bay bcde | 11 | 25 | None |

**Table 7:** The type of drug contained in cargo bay is the same as in table3.

### 4.1.2 距离

基于上面只考虑空间和负重的分析，我们提出了set of medical packages的方案。下面再结合距离信息来计算出drone fleet和至多三个ISO cargo containers的位置，这会容易一些，因为上面的分析给出了一些可能的组合，已经排除了一些组合。首先给出每种无人机的无负载最大航程（保留两位小数），如下表所示

|  |  |
| --- | --- |
| 无人机型号 | 最大航程(km) |
| A | 23.33 |
| B | 52.67 |
| C | 37.33 |
| D | 18.00 |
| E | 15.00 |
| F | 31.60 |
| G | 17.07 |

### 4.1.2 .1 无人机只携带一个投放点的医疗包的情况

这种情况我们在上面的表3里又看到，为了方便表示，用一个5行7列矩阵表示。



其中第行第列的元素代表类飞机和投放点之间的关系(A类无人机对应的,B类对应…，以此类推，a地点对应,b地点对应，以此类推)。元素为1代表类飞机可以承担投放点医疗包投放(delivery)的任务，0代表不能承担。因为是一架无人机只装载一个投放点的医疗保并且有五个投放地点，所以每天需要出动五架无人机来投放物资。设是第架无人机每天传递物资需要的航程。那么提出一个目标函数：



为了尽可能地节省能源，这个函数地值应该尽可能的小，也就是要使用优化算法实。

我们使用粒子群优化算法来解决这个问题，步骤如下：

第一步：初始化粒子群和速度，采用100组粒子群，粒子群和速度都是遵循下面的公式产生：



其中，是第个粒子群中3个粒子的纬度，是第个粒子群中3个粒子的经度， 产生三个-1到1之间的随机数，它们都是1×3的向量。是第个粒子群中3个粒子的速度，产生六个-1到1之间的随机数，它们都是1×6的向量。之所以按照上面的公式来产生初始粒子群，是因为波多黎各所跨的纬度大概是17.9度到18.5度，所跨的经度大概是-67.2到-65.6度，上面公式里面经度没有带负号，这并不会影响结果。然后要计算适应度函数的值，计算方法如下：

遍历三个ISO cargo containers，五个投放点和7中无人机的所有可能性。在所有的遍历中，首先要保证类型无人机可以承担投放点的运输任务，也就是，然后还要保证无人机的航程是够的，在这一步里面，为了尽量减少航程，无人机完成运输任务之后的返航地点可以和起飞地点不一样，选择的是离投放点最近的ISO cargo container，这样做的话，第二天的航线就会发生变化，但是仍然还是可以飞的，举个例子，第一天从ISO1位置飞到第1个投放点，然后飞回ISO2，那么第二天就可以从ISO2飞到投放点1，然后飞回ISO1，第三天就和第一天一样了，这样每两天是一个周期。如果这样做，需要满足：





其中表示的是第个ISO cargo container和投放点之间的距离，表示的是所有的ISO cargo container离投放点的距离中最短的距离，表示的是类型无人机的载重最大航程，是类型无人机的载重最大航程, 是类型无人机的载最大负重量，是投放点所需的医疗包的重量，是一个系数，本文中取。根据前面的假设，的计算公式如下：



其中, 和分别是投放点的纬度和经度，和分别是第个ISO cargo container的纬度和经度，是单位纬度的距离(km)，是单位经度的距离(km)。





其中是地球半径，取km。然后还要保证每天五个地点的医疗包供应，五个地点的供应情况用1×5的向量来表示，它的第个元素表示第个地点是否接受到供给，第个元素等于1，表示这个地点每天的需求得到满足，如果等于0，则需求没有得到满足。可以通过的五个元素的和来表征整体的供应情况。



或者可以写为：



其中，为取整函数，除了考虑投放点物资运输任务外，还要考虑ISO cargo container的位置要和五个投放点之间的最近距离大于3km。这个条件的满足与否用来表示。



其中是3个ISO cargo container分别和五个投放点之间距离的最小值。而且，还要保证求出的ISO cargo container的位置应该在岛内。首先找到波多黎各这个岛的边界的闭合曲线，然后判断求出的点是否在这个闭合曲线内部。边界的闭合曲线通过找这个岛屿边界上的一些点的经纬度，然后分段插值得到，下面是插值得到的边界和实际边界的一个对比情况：





这个形状还是比较符合的。然后通过MATLAB的inpolygon函数来判断三个ISO cargo container的位置是否在闭合曲线内部。如果都在的话，，如果有任何一个ISO cargo

container不在岛内，。

最后的适应度函数：



是一个正数，本文中取。

优化目标是让适应度函数尽可能的大，求的是。

第二步：求个体极值和群体极值。因为是刚刚初始化，个体极值就是初始化的值，群体极值是在100个粒子群中找到适应度函数值最大的一组。设个体最优值向量为,群体最优值为。

第三步：迭代计算,本文中迭代次数取5000次和10000次分别优化一次。先进行速度更新，速度更新公式为:



其中，表示第次迭代时第组粒子的速度，它是1×6的向量，初始产生的粒子按照处理，,为两个正系数，本文中取，，为两个随机的正数，每次迭代产生一次，本文中均采用MATLAB中的rand函数产生0-1之间均匀分布的随机数。是第次迭代第个粒子组的个体最优解向量，表示第次迭代第个粒子组坐标向量，表示第次迭代的群体最优解向量，它们都是1×6的向量。是第次迭代时速度更新的权重，刚开始迭代时，这个值应该较大，有利于全局搜索，找出全局最优解的可能存在区域，迭代次数比较大的时候，这个值应该较小，有利于局部精细搜索，精准定位到全局最优解。本文中的随迭代次数的变化为：



其中，，为迭代总次数。当时，的变化趋势如下图：



速度更新的时候，需要添加一些速度限制条件，根据波多黎各所跨经纬度情况，采取的速度限制为：



其中为速度在纬度方向上的分量，为速度在经度方向上的分量，如果超过限定范围，就取最近的边界值。然后是粒子群位置向量更新：



位置更新的时候同样需要遵循一定的限制条件。



其中是每一个粒子的纬度，是每一个粒子的经度，如果不在范围，还是取最近的边界值。然后再对新的粒子群计算一次适应度，更新个体最优解和群体最优解，进入下一次迭代。

上面是整个粒子群算法的过程。取时，最后得出的效果如图：



横轴为迭代次数，纵轴为群体最优适应度函数的值，看到一开始迭代的时候适应度为0，说明没有满足上面的条件，然后不到500次的时候开始有满足条件的粒子组出现，适应度函数值出现阶跃式增长，在2500次左右趋于平稳。下图展示了最后算出来的三个位置和5个投放点之间的位置关系和5条航线。

图中p1,p2,p3,p4,p5分别代表5个投放点。最后的适应度函数和三个ISO cargo containers的位置如下表所示：

|  |  |  |
| --- | --- | --- |
| ISO | 纬度 | 经度 |
| 1 | 18.3418 | 65.6756 |
| 2 | 18.2920 | 66.1364 |
| 3 | 18.3281 | 66.6560 |
| 最后的适应度函数值 | 6.5321 |  |

MATLAB计算出来的ISO cargo containers的无人机种类和数量用下列矩阵表示：



的第行第列的元素的十位表示第个ISO cargo container处前往第个投放点的无人机种类，1代表A类，2代表B类，以此类推，个位表示返航的ISO cargo container的编号，上面的结果看到每一架无人机起飞和降落的ISO都是一样的，没有出现起飞点和返航点不一样的情况，虽然起飞点和返航点不一样的情况是允许存在的。

时：





|  |  |  |
| --- | --- | --- |
| ISO | 纬度 | 经度 |
| 1 | 18.2920 | 66.1364 |
| 2 | 18.3134 | 65.6724 |
| 3 | 18.3524 | 66.8416 |
| 最后的适应度函数值 | 6.5322 |  |

这个最后的群体最优适应度函数要比5000次的稍微大一点，这个和粒子群算法的随机性有一定关系，首先初始粒子群具有随机性，而且速度更新也具有一定的随机性，所以最后可能是在全局最优解的邻域里面游走，迭代次数增加可以一定程度上减少随机性带来的影响，使最后的结果更靠近全局最优解。



### 4.1.2 .1 无人机携带两个投放点的医疗包的情况

这种情况是肯定要比无人机只携带一个投放点医疗包的情况最后计算出来的总飞行距离要短的，因为这样会节省一个无人机起飞和返航的距离。根据上面空间和负重的分析，为了方便表示，我们用三维数组表示可以承担两个地点物资运输任务的无人机：



其中是一个1×7的向量，其中的元素为1则代表对应的无人机可以承担和两地的物资运输。时， ，并且。根据上面的表4。













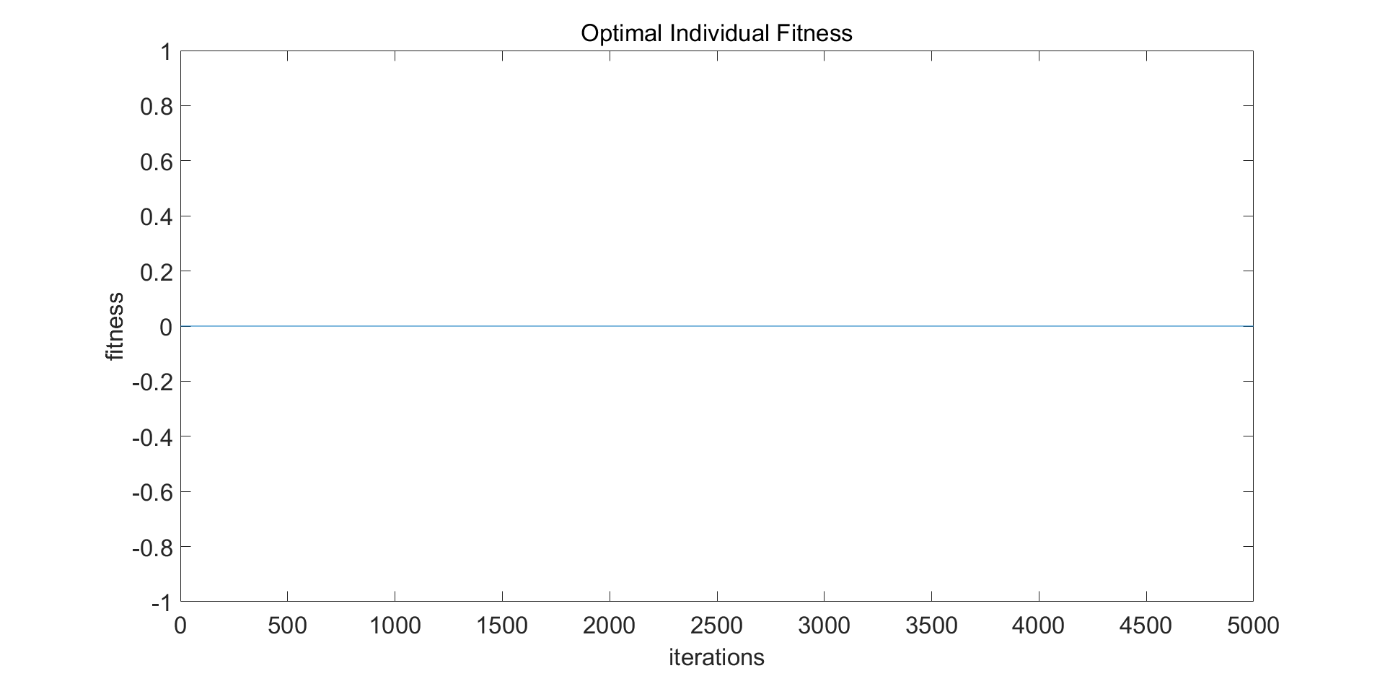






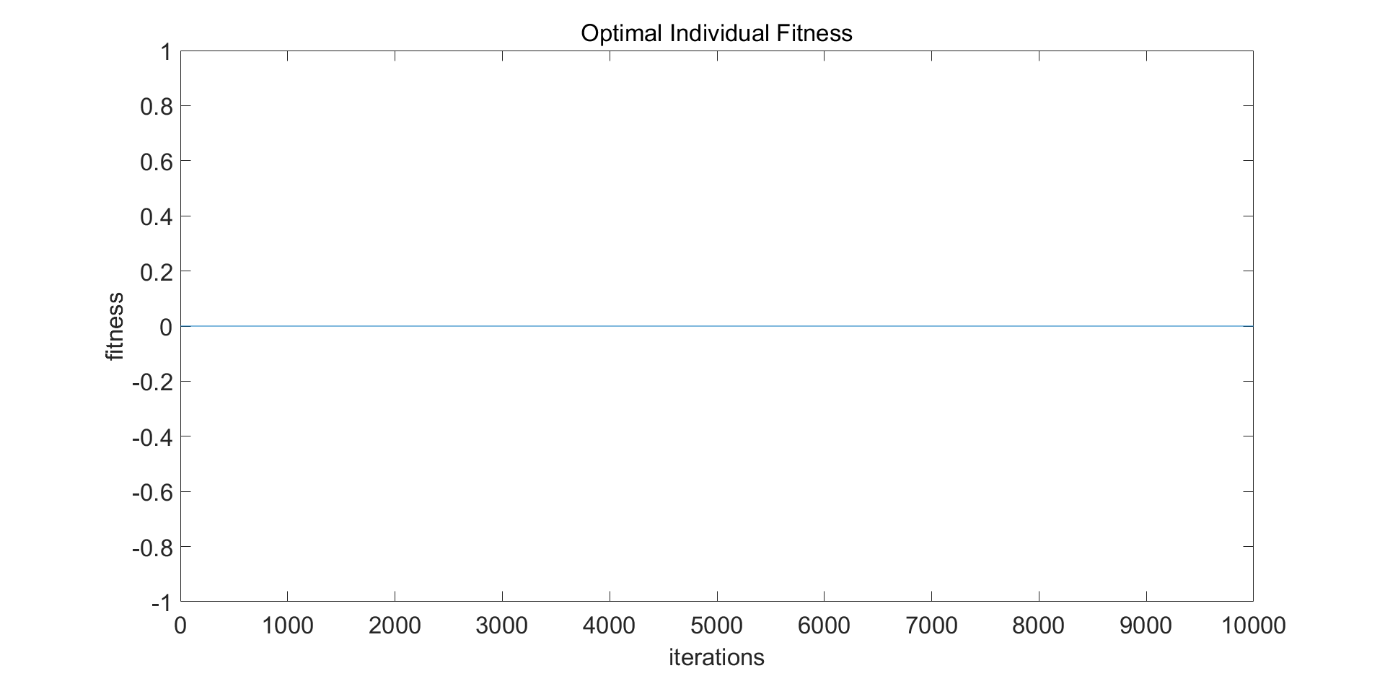


然后也是进行粒子群优化，使适应度函数最大。时：



可以看到适应度函数一直是0，说明没有可以满足距离条件的组合。粒子群算法的有一定的随机性，为了尽量避免这种随机性的影响，增大迭代次数。

时



看到适应度函数从头到尾一直都是0。那么就可以比较可信地说明，一个无人机上携带两个地点地物资去运输是不可能的，因为距离太远。2个不可能，那么3个的情况更不可能，因为3个的距离会更远，负重更重（这个导致无人机的最大载重航程更小），对空间的要求更大。