# Research on the Location Problem of E-commerce Distribution Centres Based on Fruit Fly Optimization Algorithm

**Xiaomei Tao**

Vocational college, Shanghai Jianqiao University, Hucheng Ring Road, Pudong New Area, Shanghai, China

19111@gench.edu.cn

**Keywords:** Fruit fly optimization algorithm, Distribution centre, Fresh food, Location selection

**Abstract:** With the development of e-commerce and the improvement of logistics delivery level, the position of distribution centres in the logistics network is becoming increasingly important. How to choose a scientifically reasonable delivery centre address is an important issue in the field of logistics. This article proposes a distribution centre location method based on the fruit fly optimization algorithm for e-commerce distribution centres, which combines the global optimization performance of the fruit fly optimization algorithm with the distribution centre optimization problem. Taking the e-commerce site selection problem in Hefei as an example for example analysis, the results show that this method can effectively solve the optimization site selection problem, providing an effective approach to solve the problem, making the location of fresh food distribution centres more scientific and reasonable.

## 1. Introduction

Under the background of "Internet plus" policy support, China's fresh food e-commerce (referred to as fresh food e-commerce) has developed rapidly, forming four main e-commerce models: platform fresh food e-commerce, regional fresh food e-commerce, logistics fresh food e-commerce, and traditional channel fresh food e-commerce[1]. The efficiency progress and improvement of logistics services, as well as the rapid development of e-commerce, are mutually reinforcing. One of the core issues in improving e-commerce services is the location selection of logistics distribution centres[2-3]. Therefore, reasonable location selection of distribution centres for e-commerce enterprises has become the key to improving their material distribution efficiency, increasing customer satisfaction, effectively reducing distribution costs, and enhancing their core competitiveness.

The location selection of a distribution centre is within a designated area, determining the demand conditions for a standardized area, and selecting a more suitable service location within the standardized area based on the demand conditions, in order to achieve the optimal distribution efficiency and cost from the service location to consumers[4]. The selection of a distribution centre requires consideration of many complex factors, such as the time spent from the distribution point to the customer's location, the distance required for delivery, the distance between the distribution point and the demand point's home, as well as political and economic policy requirements and natural conditions constraints. In recent years, complex swarm artificial intelligence algorithms, represented by various technological means such as artificial ant colony intelligence algorithms, particle swarm intelligence algorithms, and artificial bee colony intelligence algorithms, have been continuously innovatively formed and gradually developed, and applied to path optimization. Pan proposed the fruit fly optimization algorithm FOA in 2011[5-6]. This method is inspired by the behaviour of fruit flies, which first search for food based on scent (up to 40 kilometres long), then approach the food, continue to search for more odorous food, and finally search for food sources.

This article combines the fruit fly optimization algorithm with the location problem of e-commerce distribution service centres, and proposes an e-commerce distribution centre location method based on the fruit fly optimization algorithm. Firstly, the basic principle of the fruit fly optimization algorithm is introduced, followed by raising questions, introducing the background of

  DOI: 10.25236/icetmr.2023.030

location selection, and modelling and solving based on the FOA method. Finally, further research prospects are proposed.

## 2. Fruit Fly Optimization Algorithm

The Fruit Fly Optimization Algorithm (FOA) is a new method for fruit flies to search for food based on their sense of smell. The steps for the fruit fly population to iteratively search for food are as follows[7-8]:

(1) Randomly initialize the position of the fruit fly population.

$$\text{Init X\_axis} \tag{1}$$

$$\text{Init Y\_axis} \tag{2}$$

(2) The study gave human fruit flies a new individuality and used their olfactory function to discover an important random property in searching for human food, such as distance and direction of movement.

$$X_i = \text{X\_axis} + \text{Random Value} \tag{3}$$

$$Y_i = \text{Y\_axis} + \text{Random Value} \tag{4}$$

(3) Due to our inability to accurately calculate the elemental content and origin position of all origin foods, we first need to accurately estimate the distance (Dist) between them and the origin of the food. Then, we need to calculate the various flavours and concentrations of all foods in sequence and determine the final value (s). The difference calculated is an exact reciprocal of the origin distance.

$$Dist_i = \text{sqrt}(X_i\text{^}2 + Y_i\text{^}2) \tag{5}$$

$$S_i = 1/\ Disti \tag{6}$$

(4) It can also be used as a probability value (s) to represent the mixing concentration of substituted flavours. It can also be used as a probability function (or simply referred to as fitness function) to represent the mixing concentration of substituted flavours in this era of fruit flies, in order to facilitate us to obtain the $Smell_i$ of the mixing concentration of substituted flavours at the respective designated positions of fruit flies at this time.

$$Smell_i = \text{Function}(S_i) \tag{7}$$

(5) Finding the fruit fly with the highest taste concentration in this population (find the extreme value).

$$[\text{bestSmell bestIndex}] = \max(\text{Smell}) \tag{8}$$

(6) Preserve the optimal flavour concentration value and the coordinates of x and y, and at this point, the fruit fly population uses vision to fly towards that position.

$$\text{Smellbest} = \text{bestSmell} \tag{9}$$

$$\text{X\_axis} = X(\text{bestIndex}) \tag{10}$$

$$\text{Y\_axis} = Y(\text{bestIndex}) \tag{11}$$

(7) Then enter the replacement iteration search optimization, repeat steps 2-5 above, and determine whether the flavour concentration is higher than the previous replacement flavour. If so, repeat step 6 above.

## 3. Case Study

### 3.1. Background

A fresh food enterprise is expected to build a fresh product sales store in Hefei, Anhui Province.

And we plan to build a distribution centre in 2024[9-10]. The construction requirements of the distribution centre include: 1. meeting the daily fresh food requirements for residents in various areas to the maximum extent possible; 2. Minimize construction costs and optimize vehicle transportation costs and time. Through on-site investigation of a series of factors such as geography, environment, culture, and economic development in Hefei, the company ultimately selected the destination as P1, P2, P3, and P4.

### 3.2. Modelling of Site Selection Issues

According to the ratio of 1:2000, determine the coordinate addresses and distances of the four destinations as shown in the table 1 below.

Table 1 Distance of fruit and vegetable distribution centre.

| Delivery demand points | Coordinate(X,Y) | Distance |
|---|---|---|
| P1 | (3.86,4.65) | $\sqrt{(X-3.86)^2+(Y-4.65)^2}$ |
| P2 | (5.05,3.92) | $\sqrt{(X-5.05)^2+(Y-3.92)^2}$ |
| P3 | (2.13,3.36) | $\sqrt{(X-2.13)^2+(Y-3.36)^2}$ |
| P4 | (4.07,3.04) | $\sqrt{(X-4.07)^2+(Y-3.04)^2}$ |

The determination of the final distribution centre location is not only influenced by the demand for fruits and vegetables and the fixed cost of sales stores, but also by the distance and freight from the distribution centre to each sales store. Therefore, based on the actual costs that may arise during transportation, we define these factors as: location parameter values. Due to the different parameter values from the distribution centre to each sales store, we have created four site selection parameter tables for the four different final locations of sales stores, as shown in Tables 2~5.

Table 2 The parameters of P1.

| Parameters | The meaning of parameters | Value |
|---|---|---|
| $b$ | Transportation rate from fruit and vegetable factory to distribution centre | 1 Yuan/(ton • kilometre) |
| $P_1$ | Unit transportation rate of fruits and vegetables from the distribution centre to the demand point | 1.2 Yuan/(ton • kilometre) |
| $\theta$ | Freshness loss rate | 0.005 |
| $\beta 1$ | The percentage decrease in demand corresponding to each percentage decrease in freshness of fruits and vegetables | 3 |
| $L1$ | Purchase cost price of fruits and vegetables food | 10000 Yuan/ton |
| $n$ | Maximum number of distribution centres | 1 |

Table 3 The parameters of P2.

| Parameters | The meaning of parameters | Value |
|---|---|---|
| $b$ | Transportation rate from fruit and vegetable factory to distribution centre | 1 Yuan/(ton • kilometre) |
| $P_2$ | Unit transportation rate of fruits and vegetables from the distribution centre to the demand point | 1 Yuan/(ton • kilometre) |
| $\theta$ | Freshness loss rate | 0.005 |
| $\beta 2$ | The percentage decrease in demand corresponding to each percentage decrease in freshness of fruits and vegetables | 4 |
| $L2$ | Purchase cost price of fruits and vegetables food | 10000 yuan/ton |
| $n$ | Maximum number of distribution centres | 1 |

Table 4 The parameters of P3.

| Parameters | The meaning of parameters | Value |
|---|---|---|
| *b* | Transportation rate from fruit and vegetable factory to distribution centre | 1 Yuan/(ton • kilometre) |
| $P_3$ | Unit transportation rate of fruits and vegetables from the distribution centre to the demand point | 1.5 Yuan/(ton • kilometre) |
| $\theta$ | Freshness loss rate | 0.005 |
| *β3* | The percentage decrease in demand corresponding to each percentage decrease in freshness of fruits and vegetables | 3.5 |
| *L3* | Purchase cost price of fruits and vegetables food | 10000 Yuan/ton |
| *n* | Maximum number of distribution centres | 1 |

Table 5 The parameters of P4.

| Parameters | The meaning of parameters | Value |
|---|---|---|
| *b* | Transportation rate from fruit and vegetable factory to distribution centre | 1 Yuan/(ton • kilometre) |
| $P_4$ | Unit transportation rate of fruits and vegetables from the distribution centre to the demand point | 1 Yuan/(ton • kilometre) |
| $\theta$ | Freshness loss rate | 0.005 |
| *B4* | The percentage decrease in demand corresponding to each percentage decrease in freshness of fruits and vegetables | 2.5 |
| *L4* | Purchase cost price of fruits and vegetables food | 10000 yuan/ton |
| *n* | Maximum number of distribution centres | 1 |

### 3.3. Solving with FOA

The solution based on the fruit fly optimization algorithm uses Matlab as the platform and the fruit fly optimization algorithm as the foundation to solve the location problem of distribution centres.

(1) Objective function modelling

Distance from distribution centre to fruit and vegetable factory:

$$\sqrt{(x-2.12)^2+(y-2.79)^2} \tag{12}$$

The total demand for the four sales stores is 977.05T

Transportation cost from distribution centre to fruit and vegetable factory:

Total cost=P1_cost+P2_cost+P3_cost+P4_cost + transportation cost from distribution centre to fruit and vegetable factory

=P1 (fixed cost $C_1$, transportation cost $b_1$, loss cost) $\beta_1$. Purchase cost $L_1$)

+P2 (fixed cost $C_2$, transportation cost $b_2$, loss cost) $\beta_2$. Purchase cost $L_2$)

+P3 (fixed cost $C_3$, transportation cost $b_3$, loss cost) $\beta_3$. Purchase cost $L_3$)

+P4 (fixed cost $C_4$, transportation cost $b_4$, loss cost) $\beta_4$. Purchase cost $L_4$)

(2) Drosophila optimization algorithm solving

Initialize the fruit fly optimization algorithm, with an iteration algebra of *maxgen*=300 and a population size of size *pop*=100. Initialize two 1*2 two-dimensional array structures: X_ Axis and Y_ Axis represents the coordinate axes *x* and *y* of the site selection point. The initialization method is as follows:

$$X\_axis=10*rand(1,2) \tag{13}$$

$$Y\_axis=10*rand(1,2) \tag{14}$$

The optimization curve of the fruit fly algorithm is shown in Figure 1 below. It can be seen that after 300 generations of optimization, the objective function has decreased from low to stable. The optimal cost is 2482+10190872=10193354.

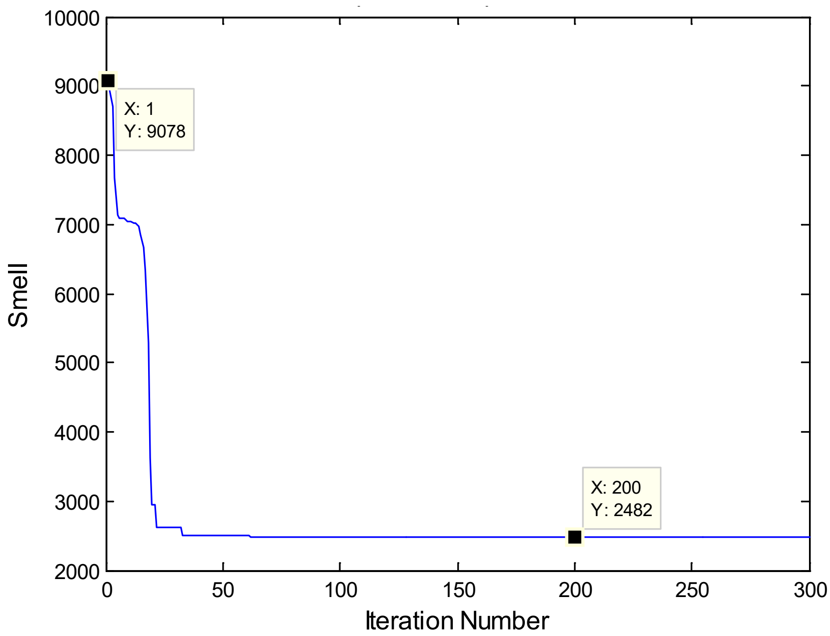


Figure 1 The optimization curve of FOA.

After 300 generations of optimization, the final fruit fly coordinates representing the x-axis are (-0.3365, 0.2432), and the fruit fly coordinates representing the y-axis are (0.2995, 0.2498). According to the principle of fruit fly optimization algorithm, calculate the distance between two fruit flies and the origin, as follows:

$$d_1= (-0.3365\text{^}2+0.2432\text{^}2)\text{^}^{0.5}=0.4505 \tag{15}$$

$$d_2= (0.2995\text{^}2+0.2498\text{^}2)\text{^}^{0.5}=0.3486 \tag{16}$$

Therefore, after the optimization of the Drosophila algorithm, the optimal coordinate values were calculated as (2.2197, 2.8682). The schematic diagram of the site selection results is shown in Figure 2 below.

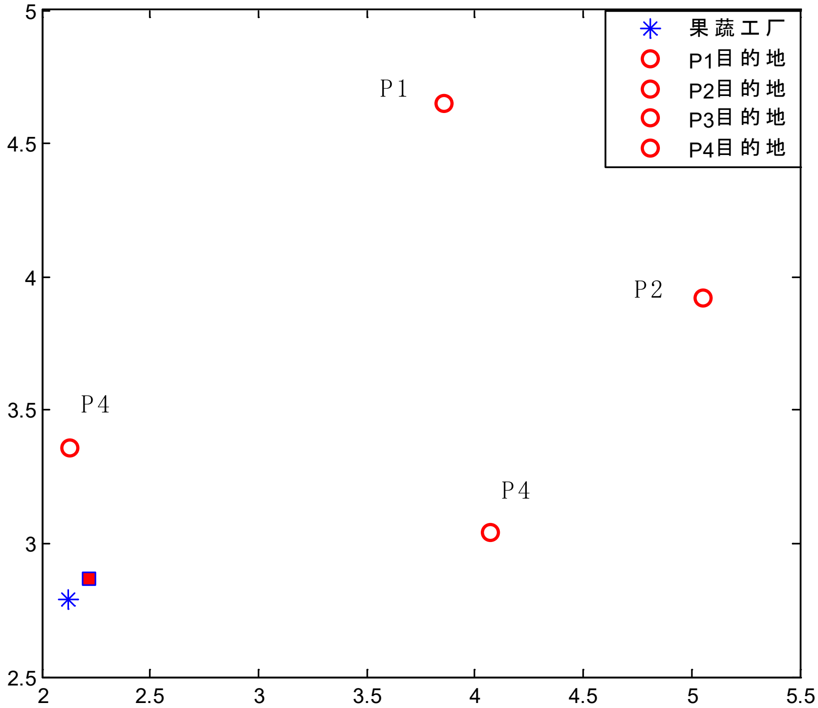


Figure 2 The optimization address schematic diagram.

## 4. Conclusion

This article combines the fruit fly optimization algorithm with the location problem of fresh e-commerce, and proposes an e-commerce distribution centre location method based on fruit fly optimization. Taking fresh e-commerce in Hefei as an example. Through modelling and analysis, the problem of site selection has been effectively solved. In the next step of research, further consideration will be given to the location problem under the influence of complex factors.


## Acknowledgements

I'd like to express my sincere thanks to all those who have lent me hands in the course of my writing this paper.


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