[International Journal of Computer and Communication Technology](https://www.interscience.in/ijcct)

Volume 8 | Issue 4 Article 7

November 2022

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Recommended Citation

Ya, Xie; Lijun, Pan; and Degang, XU (2022) "Food emergency dispatching method based on optimized fireworks algorithm," *International Journal of Computer and Communication Technology*: Vol. 8: Iss. 4, Article 7.
DOI: 10.47893/IJCCT.2022.1450
Available at: https://www.interscience.in/ijcct/vol8/iss4/7

Food emergency dispatching method based on optimized fireworks algorithm

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Abstract： In order to solve the problem of food emergency dispatching under emergencies, a food emergency dispatching method based on the optimal fireworks algorithm was proposed. The fitness function was used to measure the individual merits of fireworks, the tabu table was set to avoid the fireworks algorithm falling into the local optimal, and the tournament strategy was adopted as the iterative strategy of fireworks population. The goal of the fitness function is to maximize the satisfaction of demand points andminimize the vehicle travel time.In order to accurately predict the amount of food required at the point of demand, an infectious disease model (SEIR) was used.By comparing with the basic fireworks algorithm and genetic algorithm, the simulation results show that the proposed algorithm has higher computational efficiency and can be used in food emergency dispatching.

Keywords：optimized fireworks algorithm; emergency dispatching; food

In recent years, global emergencies have erupted frequently, causing serious impacts on human normal life. In order to actively and effectively respond to various emergencies, food emergency dispatching methods have become a hot topic of research by scholars. In addition to several basic elements such as demand points, supply points, and food, emergency dispatching problems also require constraints on vehicle load, resource types, and arrival time, as well as objective functions to determine the fastest arrival time or shortest distance. The purpose of emergency dispatching is to utilize the existing resources and conditions of the supply point, take effective measures, and scientifically deliver the food required by the demand point to the destination in the rescue work when an emergency occurs. Compared with ordinary logistics transportation, food emergency dispatching has the following characteristics: suddenness, uncertainty, unconventional, weak economy, limited resources, etc.

The existing food emergency dispatching method usually have low calculation efficiency, and it is difficult to meet the requirements of increasing food emergency. And this paper proposes an optimized fireworks algorithm to further improve the computational efficiency of the food emergency dispatching method.

1 Literature review

The research of emergency dispatching problem has gradually changed from the past precise algorithm solution to the present heuristic algorithm solution[1-2]. Instead of using the original rules of intelligent algorithm for step-by-step solution, it is further solved after relevant optimization according to the advantages and disadvantages of different algorithms. Rivera established two mixed integer linear models and developed a shortest path formula based on resource constraints to solve the resource-constrained shortest path problem[3]. The research results show that this method is superior to commercial MIP solvers and has high efficiency. Wang proposed a two-dimensional multi-objective optimization model with time minimization and cost minimization as the objectives, and adopted the rescue point decomposition method to reduce the dimension of the model[4]. Finally, the ideal point algorithm was used to solve the problem. The rationality of the model and the effectiveness of the algorithm were proved by simulation calculation. In order to effectively deal with the traffic problem of emergency vehicles, Chakraborty proposed a dynamic traffic signal control algorithm[5]. The wireless sensor network technology was used to monitor the traffic in real time and determine whether the moving vehicle was an emergency vehicle. Finally, the algorithm was used to solve the problem under the consideration of deadlock.

In order to solve the multi-objective path optimization problem of minimizing loss under the premise of minimum resource dispatching time, Qi combined ACS and PLS algorithm to design an improved multi-objective ant colony algorithm[6-7]. In the simulation calculation, the comparison with the original ant colony algorithm proved that this method has unique advantages and has strong adaptability in practical application. Feng established a dual-objective optimization model with the objectives of minimizing the total transportation distance and minimizing the cost, and converted the dual-objective problem into a single-objective problem by using the variable weighting algorithm, reducing the complexity of the multi-objective optimization problem[8]. Finally, the superiority and feasibility of the model and algorithm were proved by experiments. In order to efficiently solve the emergency dispatching problem of ambulances, Issam established a new mathematical model of vehicle routing, used *K*-Means algorithm to classify the data, analyzed the characteristics of simulated annealing algorithm and tabu search algorithm, and combined the two algorithms[9]. In the end, a scheme is proposed to search and optimize the path using simulated Anneal-Tabu search algorithm (SA-TS)[10]. The simulation results show that compared with particle swarm optimization algorithm and genetic algorithm, the proposed algorithm has better performance.

In this paper, an optimized fireworks algorithm (OPT-FWA) combining genetic algorithm and tabu search algorithm is proposed. Based on the fireworks algorithm as the framework, the solution results are represented by the numerical order of fireworks individuals. The cross mutation strategy in genetic algorithm is used to replace the Gaussian mutation operator in traditional fireworks algorithm, and the concept of tabu table is introduced. The model can be solved more accurately and effectively.

2. Prediction model based on SEIR

In this paper, SEIR

(Susceptible-Exposed-Infected-Removed) model is used to forecast the quantity of food demand, thereby indirectly predicting the quantity of food required at each demand point. The SEIR model divides the population of a certain area into four categories: residents with little food reserves (*S*), residents with food shortages (*E*), residents with zero food supplies (*I*), and residents with access to food supplies (*R*).

The dynamic model of SEIR can be expressed by formula (1):

$$\begin{cases} S_j(t)=S_j(t-1)-\lambda S_j(t-1)(I_{j1}(t-1)+I_{j2}(t-1))-\lambda_1 S_j(t-1)E_j(t-1) \\ E_j(t)=E_j(t-1)+\lambda S_j(t-1)(I_{j1}(t-1)+I_{j2}(t-1))+\lambda_1 S_j(t-1)E_j(t-1)-\sigma(E_j(t-1)-\beta E_j(t-1))-\sigma_1 E_j(t-1)\beta \\ I_{j1}(t)=I_{j1}(t-1)+\sigma(E_j(t-1)-\beta E_j(t-1))-\mu I_{j1}(t-1) \\ I_{j2}(t)=I_{j2}(t-1)+\sigma_1 E_j(t-1)\beta-\mu_1 I_{j2}(t-1) \\ I_j(t)=I_{j1}(t)+I_{j2}(t) \\ R_j(t)=R_j(t-1)+\mu I_{j1}(t-1)+\mu_1 I_{j2}(t-1) \end{cases} \quad (1)$$

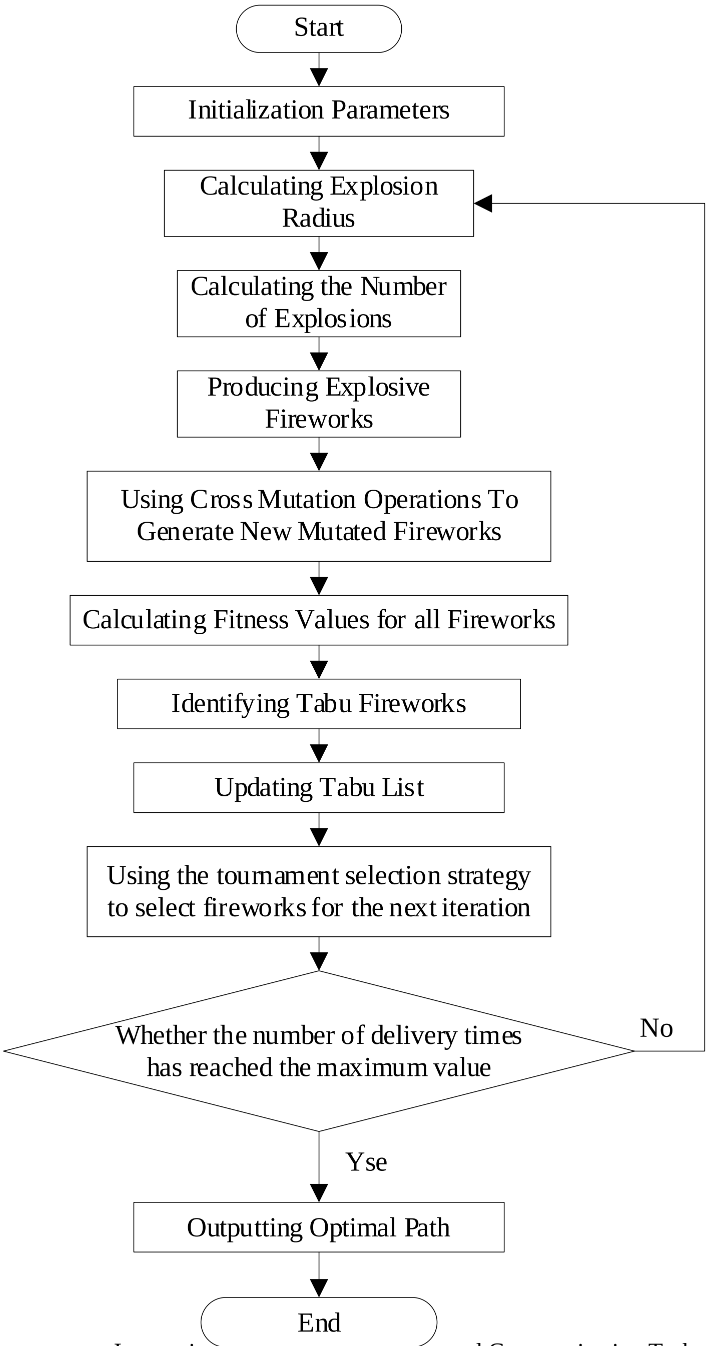
in the formula, $S_j(t)$, $E_j(t)$, $I_{j1}(t)$, $I_{j2}(t)$, $I_j(t)$, and $R_j(t)$ respectively represent the number of residents with low food reserves, those with food shortages, those in need of assistance with zero food, those with purchasing power with zero food, and those who have received food supply within a certain emergency area at time *t*, β indicates the proportion of people in need of assistance in the region, λ represents the probability that residents who lack food will become residents with zero food during a supply cycle, λ_1 represents the probability that residents with low food reserves will transform into residents with food shortages within a supply cycle, σ_1 represents the incidence of residents in need of assistance and with zero food supply, σ represents the incidence rate of residents with purchasing power and zero food consumption, μ_1 represents the probability that residents who need assistance and have zero food supply will become residents who have already received food supply, μ represents the probability of residents with purchasing power and zero food supply becoming residents who have already received food supply.

Assuming that staple food is sufficient at each demand point and only three complementary foods such as condiments, fresh vegetables and edible oil are missing, the prediction model of the quantity of food required is shown in formula (2), where $P_j(t)$ represents the total quantity of food required at the demand point *j* at time *t*, α represents the daily per capita consumption of staple food and α_1 represents the daily per capita consumption of complementary food. $I_j(t)$ represents the number of residents at the demand point *j* at time *t*, and the calculation method is shown in equation (2). $z_{1-\alpha}$ represents the service level coefficient, *L* represents the coefficient of adjustment upper limit, and *N* represents the total population of this area

$$\begin{cases} P_j(t) = a \times I_j(t) \times L + a_1 \times N \times L + z_{1-\alpha} \times s_j(t) \times \sqrt{L} \\ s_j(t) = \sqrt{\dfrac{\sum_{i=0}^{t-1}\left[P_j(t-i) - \overline{P}_j(t)\right]^2}{t}} \\ \overline{P}_j(t) = \dfrac{\sum_{i=0}^{t-1} P_j(t-i)}{t} \end{cases} \quad (2)$$

3. Optimized fireworks algorithm design

The food emergency dispatching method proposed in this paper based on the optimized fireworks algorithm is shown in Figure 1, including the following steps:



Step 1. Randomly generating n fireworks to form a fireworks population, and selecting the optimal fireworks; any fireworks represent the path for material transportation to multiple demand points.Specifically as follows:

Step 1.1. Randomly generating n fireworks based on the number of demand points a, with any fireworks X=[x_1, ..., x_a], and randomly generating a value of 0–1 for any x_i, i=(0, ..., a), and then forming an initialized fireworks X'=[x'_1,... x'_a], and multiple initialized fireworks form an initialized fireworks population; for any initialized fireworks, one x'_i represents a demand point, sorting x'_1–x'_a in ascending numerical order and connecting them in order to obtain the corresponding fireworks path; Figure 1 flow chart of OPT-FWA. For example, if material transportation needs to be carried out to 6 demand points, any fireworks can be represented as $X = [x_1, x_2, x_3, x_4, x_5, x_6]$, and if one of the fireworks is initialized as $X = [0.81, 0.90, 0.12, 0.91, 0.63, 0.09]$, then the path represented by this fireworks is

$$x'_6 \rightarrow x'_3 \rightarrow x'_5 \rightarrow x'_1 \rightarrow x'_2 \rightarrow x'_4$$

wherein x'_i represents the demand point.

Step 1.2.For any initialized fireworks, calculating the fitness value of the initialized fireworks based on the fireworks path, and selecting the initialized fireworks with the lowest fitness value from them, which is the optimal fireworks.

Step 2.Exploding the fireworks population and generating a new fireworks population based on explosion radius of the fireworks. Specifically as follows:

Step 2.1.Exploding the fireworks population and calculating the number of fireworks produced by the explosion according to formula (3).

$$S_i = M \times \frac{y_{\max} - f(x_i) + \varepsilon}{\sum_{i=1}^{N} (y_{\max} - f(x_i)) + \varepsilon} \quad (3)$$

in the formula, M is a constant that adjusts the number of fireworks produced, N is the total number of fireworks, $y_{\max}$ is the maximum fitness value among all fireworks, ε is an infinitesimal constant used to avoid zero operations, $f(x_i)$ is the fitness value of the i-th fireworks, and S_i is the number of fireworks to be produced by the i-th fireworks.

Step 2.2.Due to the fact that the result obtained by solving formula (4) is a real number, and the number generated after a fireworks explosion should be an integer, it is necessary to use formula (4) to round the real number obtained by solving formula (3).

$$\hat{S_i} = \begin{cases} round(a \times \mathrm{N}), S_i < a \times \mathrm{N} \\ round(b \times \mathrm{N}), S_i < a \times \mathrm{N}, a < b < 1 \\ round(S_i), \text{other} \end{cases} (4)$$

in the formula, a and b are the limiting factors for the number of explosions, N is the total number of fireworks, S_i is the number of fireworks to be produced by the i-th fireworks, and *round*() is rounded according to the rounding principle.

Step 2.3.Calculating the explosion radius of fireworks according to formula (5).

$$A_i = \hat{A} \times \frac{f(x_i) - y_{\min} + \varepsilon}{\sum_{i=1}^{\mathrm{N}} \left(f(x_i) - y_{\min} \right) + \varepsilon} \quad (5)$$

in the formula, A_i represents the explosion radius of the i-th fireworks, $\hat{A}$ is a constant to adjust the explosion radius, y_{min} represents the best fitness value among all fireworks, $f(x_i)$ represents the fitness value of the i-th fireworks, and ε is an infinitesimal constant to avoid zero operations;

Step 2.4. According to formula (6), obtain each new fireworks, and all new fireworks form a new fireworks population,

$$x_i' = x_i + \mathrm{A}_i \times rand(-1,1) (6)$$

in the formula, x_i' represents the location of the fireworks after the explosion of fireworks

i , x_i represents the current position of fireworks i, A_i represents the explosion radius of the i -th fireworks, and $rand(-1,1)$ represents the offset vector of the fireworks explosion, which is a uniform random number between -1 and 1.

Step 3. Performing crossover and mutation operations on each fireworks of the new fireworks population in order to obtain the mutated fireworks population. Specifically as follows: exchanging information between each fireworks of the new fireworks population and the optimal fireworks based on the crossover rate to obtain the crossed fireworks population; performing mutation operations on the crossed fireworks population based on the mutation rate to obtain the mutated fireworks population.

For example, the pending fireworks are $X = [p_6, p_2, p_5, p_1, p_3, p_4]$, and the current optimal fireworks are $P = [p_6, p_5, p_4, p_3, p_2, p_1]$. Information extraction is performed on the pending fireworks X, and the position of the extracted information is set to zero. The extracted information is set to $C = [p_2, p_5, p_1]$. At this time $X = [p_6, 0,0,0, p_3, p_4]$, searching for the information in C sequentially from the optimal fireworks, with the order of C in P being $C_1 = [p_5, p_2, p_1]$. Merging the information in C_1 into X. The fireworks after crossover operation are $X = [p_6, p_5, p_2, p_1, p_3, p_4]$, followed by mutation operation (the mutation method is to exchange two random path points in the selected individual). Setting the random mutation to exchange variables in $X(2)$ and $X(5)$, and the fireworks after random mutation operation are $[p_6, p_3, p_5, p_1, p_2, p_4]$;

Step 4: Using tabu algorithm to optimize the mutated fireworks population to obtain the optimized fireworks population. Specifically as follows:

Step 4.1. Calculating the fitness values of each fireworks in the mutated fireworks population, and selecting the fireworks with the lowest fitness value;

Step 4.2. Determining whether the fireworks with the lowest fitness value exist in the tabu list. If not, removing the fireworks with the lowest fitness value from the mutated fireworks population to obtain the optimized fireworks population. Then, listing the fireworks with the lowest fitness value in the tabu list (update the tabu list) and proceeding to step 5; if it exists, determining whether the current iteration count is greater than the tabu length. If it is greater, using the mutated fireworks population as the optimized fireworks population and proceeding to step 5. If it is not greater, removing the fireworks with the lowest fitness value from the mutated fireworks population and return to step 4.1; the preferred tabu length in this paper is 20, which means that for any fireworks determined as tabu fireworks, they will not participate in the selection operation of the next generation of fireworks in the next 20 iteration solving processes, and will be released and participate in the selection operation of the next generation of fireworks in the 21st iteration.

Step 5: Using the tournament selection strategy, n fireworks are selected from the optimized fireworks population as the next generation fireworks population. If the fitness value of the fireworks with the lowest fitness value in the next generation fireworks population is less than the fitness value of the optimal fireworks, the fireworks with the lowest fitness value will be replaced with the optimal fireworks, otherwise they will not be replaced; the specific strategies for selecting tournaments are:

Step 5.1. randomly selecting *m* fireworks from the optimized fireworks population, and selecting the fireworks with the lowest fitness value from the *m* fireworks as the next generation of fireworks; the ratio of *m* to the total number of fireworks in the optimized fireworks population is 0.6–0.8;

Step 5.2. repeating step 5.1 until the number of selected next generation fireworks reaches *n*, which is the next generation fireworks population.

Step 6: Determining whether the number of iterations has reached the maximum value (the preferred maximum number of iterations in this paper is 100). If so, outputting the transportation path corresponding to the optimal fireworks and its corresponding fitness value; otherwise, returning to step 2 and increasing number of iterations by 1. Among them, the fitness values of fireworks are all calculated based on the objective function, which is shown in equation(7).

$$F=\min\sum_{j\varepsilon D}\sum_{K\varepsilon K}\eta_1\times(P_j(t)-Y_{tkj})+t_{kij}\times Z_{kj}\times P_j(t) \quad (7)$$

in the formula, *K* represents the collection of emergency supply point vehicles; *D* represents the set of demand points; η_1 represents the penalty coefficient, whose value is the given value; $P_j(t)$ represents the quantity of food required by demand point *j* at time *t*; Y_{tkj} represents the quantity of food placed by vehicle *k* at demand point *j* at time *t*; t_{kij} represents the travel time of vehicle *k* from supply point *i* to demand point *j*, which is determined by the length of the path; Z_{kj} is a 0–1 variable that determines whether vehicle *k* has reached the demand point *j*; if vehicle *k* has reached the demand point *j*, it is 1, otherwise it is 0.

After a major event in a place, food often becomes an urgent need for residents. There are usually multiple demand points for food and a variety of demand types for food, all of which are dynamically changing. Assuming that vehicles transporting food are limited, how to plan the transportation path of vehicles is an important content of food emergency dispatch. In this paper, the optimal fireworks algorithm is used to realize food emergency dispatching.

4Algorithm performance simulation analysis

Assume that an emergency event occurs in a region, and food emergency dispatching needs to be carried out, and there are 6 food demand points. The number of residents with low food reserves, the number of residents with food shortages, the number of residents with zero food, and the number of residents with food supplies at the initial state of the six demand points are shown in Table 1, λ=0.0001, σ_1=0.4, σ=0.2, μ_1=0.03, μ=0.1. Emergency supply point *a* has two roadable vehicles, each with the same speed and a maximum load capacity of 10*t* and 9*t* respectively. The time between the supply point and each demand point is shown in Table 2.

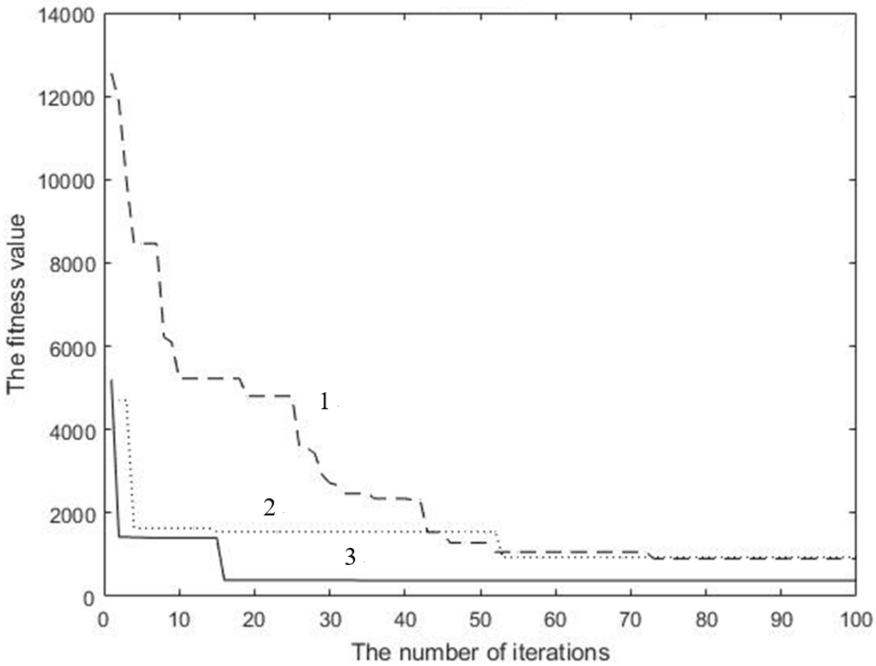
Table 1 Initial values of SEIR model

	1	2	3	4	5	6
$S(0)$	11232	13599	16997	11347	14373	10695
$E(0)$	0	0	0	0	0	0
$I(0)$	611	479	818	823	570	425
$I_1(0)$	124	97	167	684	113	86
$R(0)$	0	0	0	0	0	0

Table 2 Travel time from node *i* to node *j*

i/*j*	0	1	2	3	4	5	6
0	0	3	5	3	2	1	6
1	3	0	2	1	5	5	6
2	5	2	0	2	2	4	2
3	3	1	2	0	3	5	1
4	2	5	2	3	0	7	2
5	1	5	4	5	7	0	4
6	6	6	2	1	2	4	0

In order to verify the effectiveness of the optimized fireworks algorithm, the following simulation calculations are carried out. The relevant parameters of the optimized fireworks algorithm are as follows: number of fireworks N=20, mutation fireworks M=70, explosion number E_n=250, explosion number limiting factor a=0.4, b=1, explosion radius E_r=1500, maximum number of iterations T=100, and taboo length T_L=20. For comparison, basic fireworks algorithm (FWA) and genetic algorithm (GA) with the same parameter variables are introduced. The comparison results of the three algorithms are shown in Figure 2. The OPT-FWA algorithm, GA algorithm and FWA algorithm tend to be stable after 16, 74 and 52 iterations respectively, and the solution result of OPT-FWA is the most accurate. The optimal value is obviously lower than GA algorithm and FWA algorithm. It can be seen that the optimized fireworks algorithm can not only ensure the completion of the transportation task, but also shorten the transportation time, which can effectively save resources and reduce costs, so as to improve the efficiency of emergency food material dispatching.



1 GA 2 FWA 3 OPT-FWA

Figure 2 The calculation process of the three algorithms

The variation strategy in the traditional fireworks algorithm will replace the individual fireworks as a whole, and it is difficult to retain the excellent information in the optimal solution. However, the variation strategy in the OPT-FWA algorithm adopts the variation and crossover operations in the genetic algorithm, which can better retain some excellent information in the optimal fireworks and pass it to the next generation of fireworks, enhancing the local search ability of the algorithm. At the same time, the algorithm is further improved by using the characteristics of tabu table to avoid falling into local optimal, so as to improve the optimization ability of the algorithm.

5 conclusions

(1)A food emergency dispatching method based on the optimal fireworks algorithm was proposed. The fitness function was used to measure the individual merits of fireworks, the tabu table was set to avoid the fireworks algorithm falling into the local optimal, and the tournament strategy was adopted as the iterative strategy of fireworks population.

(2) By comparing with the basic fireworks algorithm and genetic algorithm, the simulation results show that the proposed algorithm has higher computational efficiency and can be used in food emergency dispatching.

Acknowledgements

This work was financially supported by supported by Hunan Provincial Natural Science Foundation of China（2021JJ50114）

References

[1] HU F，BAI W，TIAN C H.Two- level dispatch system ofemergency supplies with multiple objective functions using genetic algorithms[C].2015 Sixth International Conference on Intelligent Systems Design and Engineering Applications(ISDEA) ，2015：906-911.

[2] AKBARI V, SALMAN F S.Multi-vehicle synchronized arcrouting problem to restore post-disaster network connectivity[J].European Journal of Operational Research , 2017 , 257 (2)： 625-640.

[3] RIVERA J C, AFSAR H M, PRINS C.Mathematicalformulations and exact algorithm for the multitrip cumulative capacitated single- vehicle routing problem[J].European Journal of Operational Research, 2016, 249(1)：93-104.

[4] WANG H, XU R, XIONG Z, et al.Research on the optimized dispatch and transportation scheme for emergency logistics[J].Procedia Computer Science, 2018, 129：208-214.

[5] CHAKRABORTY P S, TIWARI A, SINHA P R.Adaptiveand optimized emergency vehicle dispatching algorithm for intelligent traffic management system[J].Procedia Computer Science, 2015, 57：1384- 1393.

[6] QI C, HU L.Optimization of vehicle routing problem foremergency cold chain logistics based on minimum loss[J]. Physical Communication, 2020, 40(2)：101085.

[7] DORIGO M, GAMBARDELLA L M.Ant colony system： a cooperative learning approach to the traveling sales- man problem[J].IEEE Transactions on Evolutionary Computation, 1997, 1(1)：53-66.

[8] FENG J , GAI W , LI J Y , et al.Location selection of emergency supplies repositories for emergency logistics management：a variable weighted algorithm[J].Journal of Loss Prevention in the Process Industries, 2020, 63： 104032.

[9] ISSAM Z, AL-OMANI M, ALDHAFEERI K.A new approachbased on the hybridization of simulated annealing algorithm and tabu search to solve the static ambulance routing problem[J].Procedia Computer Science, 2019, 159：1216- 1228.

[10] RAMESH C, KAMALAKANNAN R, KARTHIK R, et al.A lot streaming based flow shop scheduling problem using simulated annealing algorithm[J].Materials Today ： Proceedings, 2020.