MATEC Web of Conferences **232**, 03004 (2018) https://doi.org/10.1051/matecconf/201823203004
EITCE 2018

Application of Artificial Bee Colony Algorithm for timing of Road Entrance Signal

Chen Ming-xia[1, a], Zhang Han[1] and Li Xu-yong[1]

[1]College of Mechanical and Control Engineering, Department of Guilin University of Technology, Guilin City, the Guangxi Zhuang Autonomous Region, China

Abstract. Aiming at the problem of signal timing at road intersections, this paper uses the artificial bee colony algorithm to optimize the road model of single point multi - phase intersection. In this paper, the cost function is the weighted sum of the average delay time, the average number and the capacity. Using the artificial bee colony algorithm to optimize the signal timing of a typical crossroad, and using MATLAB experimental platform to simulate, it shows that the artificial bee algorithm can enhance the road traffic efficiency.

1 Introduction

At present, the serious traffic congestion in China brings a lot of inconvenience to people's travel. Due to the restriction of urban space, it is very difficult to expand the road. Therefore, under the condition that the land space resources are not abundant, other means should be used to solve the problem of traffic congestion. At present, a more reliable method is to control the intersection of the road that is to optimize the timing of the signal lights of the road intersection. Because of the complex types of urban road intersections, single-point intersections occupy a large proportion of urban intersections, and among many intersection models, single-point intersection is a typical road intersection model. Therefore, it is of great significance to study the traffic signal timing problem at single-point intersection.

In this paper, the artificial bee colony algorithm is used to solve the signal time model of intersection. In the process of colony foraging, the foraging bee colony can be divided into three categories, namely, the hired bee, the following bee and the detection bee. Among them, the function of the hired bee is to search for the honey source randomly and guide the search direction of the following bee. The following bee follows the scout to find the honey source. The function of the bee is to make the algorithm converge quickly; the spy bee searches the new nectar source randomly in the range of search, and can avoid the trouble of getting into the local optimal solution to some extent by the . Therefore, the artificial bee colony algorithm can greatly improve the probability of searching the global optimal solution.

2 Analysis of Road intersection model

2.1.Mean tardiness

There are many kinds of Road intersection models, and the first signal timing method is proposed by Webster. After that, the average delay time of vehicle, the average number of car parking and traffic capacity are studied, and the relevant theories are more mature and widely used in practice.

The average delay time of the road intersection has a great influence on the traffic efficiency of the road intersection, and the early Webster signal timing method is the average delay time. At present, many intelligent algorithms also take the average delay time as the optimization index to improve the traffic efficiency by optimizing the average delay time. Referring to the relevant literature, we can see that the average delay time formula is as follows. The average delay time formula is shown in (1).

$$\mathrm{D_i} = \frac{(c-x_i)^2}{2c(1-y_i)} + \frac{c-x_i}{2cq_i} + \frac{q_i c^2}{2s_i x_i (s_i x_i - q_i c)}$$

(1)

The Y_i is the traffic intensity of the I phase, that is the ratio of the traffic flow of the I phase to the saturated flow; the q_i is the phase of the phase of the I; the ratio of the green signal to the phase of the I is the ratio of the green light time to the period of the phase, and the saturation flow of s_i is the phase of the I phase.

2.2.Average Parking Number

The average number of parking times of the road intersection refers to the number of times when the normal traffic on the road stops because of the control of the traffic light signal at the intersection, that is, the rate of parking. The average number of parking can reflect

* Corresponding author:[a] Corresponding author: zhanghan368@163.com

the degree of obstruction on the road. Document [4] gives a specific calculation method, as shown in (2).

$$H_i = 0.9 \times \frac{1-g_i}{1-y_i} \tag{2}$$

The g_i is the ratio of green to signal-to-phase I, that is, the ratio of green time to cycle of each phase, and H_i is the average number of parking times, that is, the parking rate.

2.3.Traffic Capacity

The capacity of a road intersection is the maximum volume of traffic that can actually be passed in a unit time (usually one hour), which is the sum of the traffic in each lane, on one road or at a certain road section. Generally speaking, traffic capacity refers to the limits of vehicles that roads can accommodate. The traffic capacity of Road intersection is an indispensable performance index in the design, management and evaluation of a road intersection. The British transport and Road Research Institute (TRRL) has proposed a formula for estimating the capacity of road traffic, for example, (3).

$$Q_i = S_i \times \frac{x_i}{c} \tag{3}$$

The s_i is the saturated flow of the I phase; x_i is the effective green light time of the I phase; C is the intersection signal period, that is, all the signal lights need to be lighted once; Q_i is the traffic capacity of the road intersection, that is, the maximum traffic flow that is actually passed.

2.4.Objective Function

With the development and progress of the society, the current traffic network becomes more and more complex, the increase of the overall traffic flow in the city, and the mutual interference between the vehicles, making it impossible to meet the actual traffic demand only by using the above three indexes alone as the optimization index. Therefore, according to the actual situation, this paper comprehensively considers three performance indicators and the reference model based on the actual life, and through three weighted coefficients K_i^1, K_i^2, and K_i^3 that can change with the actual traffic situation, the three performance indexes are integrated into the target function. The objective function model is shown as (4).

$$\min f(x) = \sum_{i=1}^{n} \left(\frac{K_i^1 D_i + K_i^2 H_i}{K_i^3 Q_i} \right) \tag{4}$$

The constraints are as follows:

$$\mathrm{x}_{\min} \le x_i \le x_{\max}, 1 \le i \le n$$

$$\sum_{i-1}^{n} (x_i + l_i) \le c$$

$$\beta_{\min} \le \frac{y_i c}{x_i} \le \beta_{\max}, 1 \le i \le n$$

$$x_i \in z^+, 1 \le i \le n$$

X_i - effective green light time of phase I

X_{min}, X_{max} - the upper and lower limit of the effective green time of phase I.

L_i - loss time of phase I at Road intersection.

C - The signal cycle at the intersection, that is, the time required for all signals to be lit once.

The upper and lower limits of the saturation value of the intersection min and max.

2.5.Weighting Coefficient

K_i^1, K_i^2 and K_i^3 can be changed in real time according to the actual demand of traffic, so that the function values obtained after the optimization are more practical, and the effect of signal timing is better. The selection rules of three weighted coefficients in the objective function are as follows: K_i^1 and K_i^2 decrease with the increase of the phase traffic intensity of the road intersection, and K_i^3 increases with the increase of the phase traffic intensity of the road intersection.

Taking into account the above factors and literature [7], the three weight coefficients are shown in formula (5), (6), and (7).

$$K_i^1 = 2 \times (1.0 - y) \times \sqrt[7]{S_i} \tag{5}$$

$$K_i^1 = \sqrt[7]{S_i} \times \frac{1.0 - y}{0.9} \tag{6}$$

$$K_i^3 = 2 \times Y \times \frac{C}{3600} \tag{7}$$

3 Example model of Road intersection

In this paper, a typical cross - cross road is selected as an example to optimize its timing. Vehicles in each lane may choose to move forward, turn left, or turn right, as shown in Figure 1. The traffic volume of each lane is the sum of vehicles entering the lane. The saturated flow of each phase vehicle is shown in Table 1. The minimum value of the effective green light time of each phase of the intersection is determined to be 15s and the maximum value is fixed to 90s. The maximum cycle length of the road intersection is determined to be 280s, the minimum saturation value of each phase is 0.7, the maximum saturation value is fixed at 0.95, and the loss time of each phase is determined to be 5S.

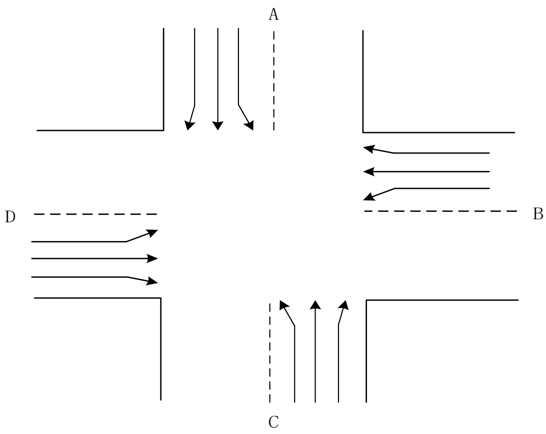

Fig.1 Road intersection diagram

Table 1 Saturation flow of each phase in Road intersection

Phase name	**A**	**B**	**C**	**D**
Saturated flow	1200	960	1200	960

4 Algorithm Steps

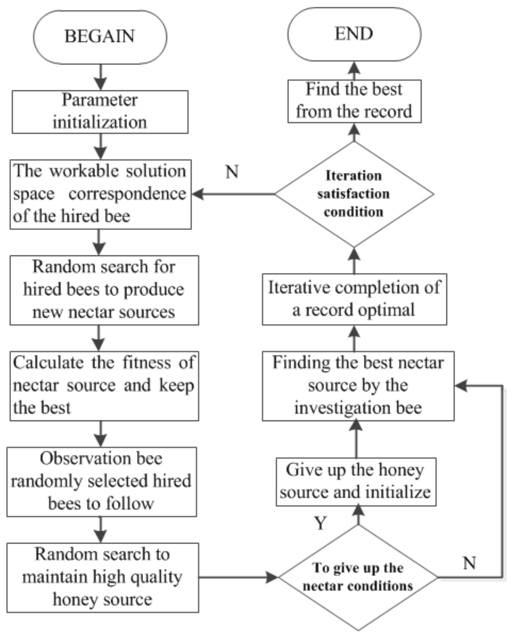

Fig.2 Flow chart of intersection model by artificial bee colony algorithm

5 Simulation experiment analysis

5.1.Determination of population number

In the simulation experiment, we refer to the test data in the related data. This data is the measured data, which is representative. Usually the range of peak flow is (0.75, 0.95], the range of the level of the flat peak flow is (0, 0.75]). In the experiment, the flow ratio is selected as y1=0.28, y2=0.12, y3=0.315, y4=0.13, and the total flow ratio is Y=0.85. As the peak flow parameter, the flow ratio is y1=0.2716, y2=0.1164, y3=0.2646, y4=0.1764, and the total flow rate is higher than Y=0.829. The total flow rate of 48 is compared to Y=0.7725 as a flat peak flow parameter, and the ratio of flow rate to y1=0.20, y2=0.120, y3=0.2250 and y4=0.135 is compared to Y=0.68 as the peak flow parameter. In the process of determining the population, the number of 1000 iterations is set according to experience. The number of population is 10, 20, 30, 40, and 50 respectively according to the empirical method. The number of population is compared with the simulation results, and the size of the population is obtained, and four cases are shown in Table 2, 3, 4 and 5.The average delay time of vehicles in the table is expressed by D, the average parking times by H, the average road capacity by Q, and the running time by time.

Table 2 Effect of population number on algorithm effect

Num	10	20	30	40	50
D H Q Fun	76.8609 0.87811 260.902 0.007828	77.6129 0.87774 261.1245 0.0079775	76.9865 0.87783 260.9876 0.0078581	77.6767 0.87727 261.1185 0.008025	77.7344 0.87769 261.3501 0.0079935
times	3.7042	5.4924	26.6155	65.5299	67.3149
Num	60	70	80	90	
D H Q Fun	77.4740 0.87761 261.1452 0.0079568	77.1735 0.87785 261.09 0.0078917	77.8855 0.87744 261.3814 0.0080365	78.1989 0.87736 261.5720 0.008096	
times	70.6420	141.0546	161.5414	161.5414	

When the population is 10, the optimization time is the shortest, and the average delay time of the vehicle is lower than the other three cases, but the capacity is also lower than the other three cases. Compared with other population size results, the fluctuation of data is larger. When the population size increases to 20, the data fluctuates slightly. The analysis shows that the road capacity is improved, but the optimization time is also increased. When the population size increased to 90, the optimization results were also more stable and less volatile. The optimization results were basically the same as the population number of 20, but the optimization time increased obviously with the increase of the population number. During the peak flow period, the utilization rate of the road is emphasized, that is, during the peak flow period; the performance of the road capacity is required to be higher. Considering the performance index of the final optimization and the time required for the optimization of the algorithm, and considering the effective and rational utilization of the computing resources, the number of selected population is 20.

5.2.Determination of the maximum number of iterations

Before the maximum iteration number is determined, the maximum iteration number is set to 1000 according to the algorithm experience, the number of population is 20, the algorithm simulation is 10 times, and the number of iterations of each simulation is shown as shown in the figure.

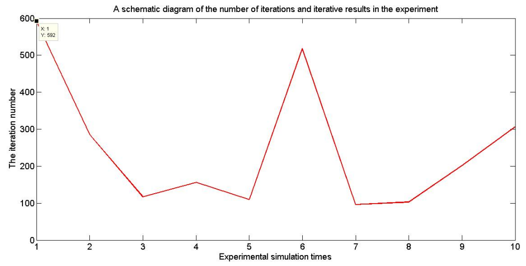

Fig.3 A schematic diagram of the number of iterations and iterative results in the experiment

From the data analysis in the table, we can see that in the 10 simulation experiment, the maximum number of iterations is 592 times. The 10 simulation experiments have certain representativeness. In the final determination of the number of iterations, the number of iterations obtained by the 10 simulation experiments has a certain reference value, and it is advisable to be 592. At the same time, considering the limitations of the 10 simulation experiments, there should be some allowance for the final iteration. The maximum iteration number is 700.

6 Experimental results and analysis

The experimental data are average, that is, the artificial swarm algorithm is used to carry out 100, 500 and 1000 simulation experiments on the road intersection model. Finally, the average value of the simulation results is taken as the optimization results of three performance indexes respectively. The results of numerical simulation are shown in Table 3, 4, and 5.

Table 3 Artificial bee colony algorithm iteratively searches 100 times performance index optimization results

Traffic flow	Fun	D	H	Q
Y=0.85	0.00791200	77.3031	0.87763	261.0849
Y=0.829	0.00925655	77.3161	0.87244	261.1039
Y=0.7725	0.0047744	34.4203	0.88392	217.3224
Y=0.68	0.0059494	37.5649	0.87015	218.2886

Table 4 Artificial bee colony algorithm iteratively searches 500 times performance index optimization results

Traffic flow	Fun	D	H	Q
Y=0.85	0.0078625	77.0048	0.87787	261.0182
Y=0.829	0.0092668	77.3616	0.87234	261.1242
Y=0.7725	0.004809	37.5930	0.883102	217.9067
Y=0.68	0.0053292	33.4539	0.86834	220.4685

Table 5 Artificial bee colony algorithm iteratively searches 1000 times performance index optimization results

Traffic flow	Fun	D	H	Q
Y=0.85	0.0080775	78.0915	0.87724	261.4386
Y=0.829	0.0092340	77.1787	0.87250	260.9839
Y=0.7725	0.0048564	37.7897	0.883530	218.0954
Y=0.68	0.0058686	37.2781	0.87044	217.9164

Considering the effect of three performance indicators on the road intersection, that is, from the objective function optimization value, the single target optimization value obtained by using artificial bee colony algorithm to optimize the signal timing of Road intersection is smaller. During the peak flow, the capacity of the intersection has been improved effectively, and the average number of parking and the average delay time of the vehicle can be reduced, thus the utilization rate of the road is improved. During the peak flow period, the average parking times and average delay time of vehicles can be reduced, so that the vehicles can pass quickly and the roads can be smoother. In this paper, the artificial bee colony algorithm is used to optimize the timing of a road intersection case model.

The results of MATLAB simulation show that the artificial bee colony algorithm can effectively improve the traffic efficiency of the road intersection, effectively improve the road capacity, the average number of parking and the average delay time, so that the objective function is made. The value is optimal. In this paper, artificial bee colony algorithm is applied to the problem of signal timing in Road intersection. Because the algorithm has the advantage of global optimization, the proposed algorithm is more reliable than other local optimal intelligent algorithms.

References

1. Li Xuejia. Traffic signal control at level crossing [J]. Journal of Career Academy, Jiamusi, 2011 (2): 417-418.
2. Huang Shaozze, Zhao Ning. Simulation Evaluation and Timing Optimization of Urban Road Intersection [J].Internet of Things, 2015. (04): 101-102.
3. Ren Xinxin, Zhou Ling, Zhao Feng, et al. Reactive power optimization of distribution network based on artificial bee colony algorithm [J].Modern Power, 2012, 29 (4): 41-45.
4. Chen Yuangao. How to improve the capacity of existing roads [J]. Vehicle and safety, 2014 (7): 48-54.
5. Yang Hairong, Luo Dayong. Signal real-time rolling optimization model and algorithm [J]. control and decision, 2014 (4): 645-650.
6. Wang Lingling, Ding Xue Yong. Simulation study on intelligent traffic signal control at intersection. [J]. technology vision, 2013 (36): 48-49.
7. Li Mudong, Xiong Wei, Guo Long. Improved DV-Hop location based on artificial bee colony algorithm [J]. Computer science, 2013, 40 (1): 33-36.
8. Ge Yu, Liang Jing, Wang Xueping. Improved artificial bee colony algorithm based on extremum optimization strategy [J].Computer Science, 2013, 40 (6): 247-251.
9. Yang Hairong, Luo Dayong. Signal real-time rolling optimization model and algorithm [J]. control and decision, 2014 (4): 645-650.