Research on the application of Genetic algorithm in traffic control

Hui Du

School of Mathematics and Statistics, Northeast Petroleum University, Heilongjiang 163000, China

duhui@163.com

Abstract. With the continuous development of our country's traffic network, the difficulty of traffic control is increasing, the use of various methods to optimize traffic control has gradually become a trend. This paper selects genetic algorithm in traffic control, and provides a more efficient design idea through the optimization of the past algorithm, in order to make a contribution to the improvement of our traffic control efficiency.

Key words: Genetic algorithm; Traffic control; Application Path.

1. Introduction (Heading 1)

The road of modern city is intricate and all kinds of roads are interwoven. In intelligent transportation, how to reasonably distribute the traffic flow of each section to achieve the maximum traffic flow is the key of intelligent transportation. In this paper, a number of interconnected roads are regarded as a whole, and the maximum average flow of each road is calculated by using the optimal mathematical model. Due to the large scale of the system and the existence of multiple equality constraints, it needs to be converted into a multi-objective optimal model and introduced into the hybrid genetic algorithm based on niche.

2. Background of Research

In our country, especially in big cities, traffic congestion problem is becoming more serious by day, becoming a serious problem facing nowadays. Urban transportation system is not perfect, will directly affect the city's development, construction, people's life and local economic development. Therefore, the traffic problem is the current hot and difficult problem. At present, many cities regulate the traffic signals by establishing the optimal model of the intersection, intelligent algorithm, fuzzy operation and other methods, so that the vehicle stay time is minimum, but this method is limited to one or more traffic signals within the control range. Due to the limited capacity of the intersection, the intelligent traffic control signal loses its function when the traffic flow reaches or exceeds the maximum capacity. So, in addition to improving traffic efficiency through intelligent traffic control and traffic diversion, it is also necessary to check at the source. Therefore, it is not enough to know how to realize intelligent control at some intersections. This paper must study the maximum capacity of the whole system. When the optimal running time of a transportation system is calculated, that is, the maximum carrying capacity of the road, the vehicles entering the system can be controlled and the operating efficiency on the main road can be optimized [1].

3. Traffic network model and algorithm implementation

3.1 The presentation of a problem

First, this paper studies the transportation system composed of m+n intersecting roads, and then abstracts it as mn network. The specific effect is shown in Figure

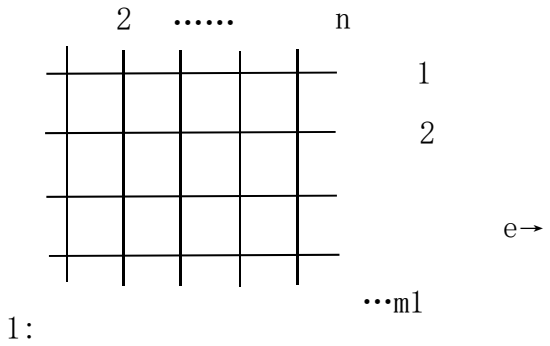


Fig. 1 Grid model 1

The lines in the figure are highways, and the intersections of lines are intersections (currently most roads in our country are cross or T-intersection). This paper assumes that there are m roads in the transverse direction and n roads in the longitudinal direction. Think of east-west traffic as a horizontal flow, and west-bound traffic as a vertical flow. In this way, the phases of the intersection are simplified into two types: east-west and longitudinal. In a certain section, the traffic flow is not uniform, but is divided into several sections by intersections. Therefore, in this paper, an observation station is set between each intersection and the traffic flow of the intersection is set as cij respectively. Therefore, this paper takes the average value of the traffic flow of each section as the average flow of the whole road. namely: $c_i=\frac{c_{i1}+c_{i2}+\ldots c_{in}}{n}$.

In this paper, the average east-west traffic flow is set as a1, a2…am sets the average traffic flow in the north-south direction as b1, b2…bn. The average passing time for crossing vehicles at any intersection is t_{ij}^e(i=1,2…m,j=1,2…n), The traffic time in the vertical direction is t_{ij}^r. So, in a cycle, the average lateral dwell time at each intersection is $S_{ji}^e=\max(a_i \cdot T_{ij}-V_{ij}^e \cdot t_{ij}^e, 0)$; In the vertical direction, the average residence time is:

$$S_{ij}^r=(b_j \cdot T_{ij}-v_{ij}^r \cdot t_{ij}^r, 0)$$

So, at an intersection, the total latency is $S_{ij}=S_{ij}^e+S_{ij}^r \cdot T_{ij}. a_i \cdot T_{ij}, b_j \cdot T_{ij}$ Are the number of vehicles arriving at the intersection in a period of time, from transverse to longitudinal. v_{ij}^e, v_{ij}^r Is the maximum lateral traffic flow refers to the traffic flow at the intersection, that is, the passing capacity. Since a T-junction can also be divided into horizontal and vertical traffic, there is only one road where the traffic does not travel in a straight line, but at a bend, so it can be converted into an intersection.

3.2 Establishment of model

The objective of this paper is to maximize the average flow of the entire traffic system (that is, to require the maximum pass rate of the system) without causing congestion at any intersections. If the traffic on this road cannot be cleared in time, then as time goes by, more and more vehicles will be on other roads, and eventually the whole traffic system will be paralyzed. Therefore, this paper wants to achieve a maximum traffic volume of: $\max(\sum_{i=1}^m a_i+\sum_{j=1}^n b_j)$, In an average cycle, the holdup time at each intersection must be zero, Is also: Sij=0.

Since the maximum flow from one intersection to another intersection is Cij. So the total traffic that includes this section is $a_i \cdot T_{ij} \le C_{ij}^1$ and $b_j \cdot T_{ij} \le C_{ij}^2$. The average time of transverse and longitudinal release at intersections should also be kept within a certain range, that is $d_1 \le T_{ij}^e, t_{ij}^r \le d_2$. The overall model constructed in this paper is:

$$\begin{cases} \max(\sum_{i=1}^m a_1 + \sum_{j=1}^n b_j) \\ \sum_{i=1,j=1}^{mn} S_{ij} = 0 \\ d_1 \le t_{ij}^e, t_{ij}^r \le d_2 \\ a_i \cdot T_{ij} \le C_{ij}^1, b_j \cdot T_{ij} \le C_{ij}^2 \end{cases} \quad (1)$$

In this model, the vehicle dwell time at each intersection is 0. If there are more than one intersection, then there is a constraint of more than one formula.

3.3 Concrete example

This paper assumes a three-vertical and three-horizontal urban network, with a T-shaped intersection at the lower right. The specific model is shown in Figure 2:

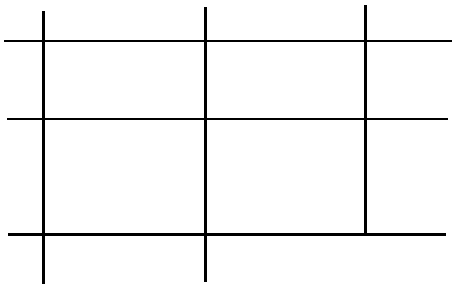


Fig. 2 Grid model 2

In the horizontal direction, the average flow of the three highways is respectively: 1a, 2a, 3a, In the vertical direction, they are respectively: 1b, 2b, 3b. According to the above model, the average residence time of each intersection is Sij. Due to the structural characteristics of each intersection, the maximum traffic volume changes, so the traffic volume of each intersection is also different. This paper assumes that the transverse and longitudinal traffic capacity of each intersection is 2.2, 2.2, 1.9, 2, 2, 2.1, 2, 2, respectively. 1.5, Unit cars per second. At the T-junction on the lower right, 1.5 cars per second. The driving interval of each intersection and T-junction is set as 120s, 90s. The population number was set to 60, the overall iteration was 500 times, the generation gap was set to 0.9, the selection probability was set to 0.85, and the mutation probability was set to 0.04. After several operations, the best results were obtained, as shown in Figure 3 and Figure 4 respectively. Each point in the graph represents the value that a population is searching for. The ordinate is the stranded vehicles in units, and the abscissa is the traffic volume in units per second. As shown in Figure 3, the residence time of vehicles is 5.6574, while the maximum flow rate of vehicles is 3.5256 vehicles per second. In Figure 4, the number of stops is 0.1566 and the maximum traffic flow is 3.618 vehicles per second.

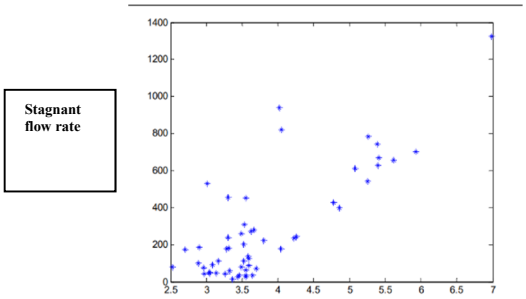


Fig. 3 Residual quantity scatter diagram 1

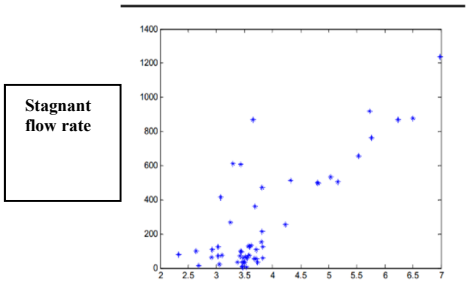


Fig. 4 Residual quantity scatter Figure 2

As you can see from the two diagrams above, there is no point with zero stops in Figure 3, which indicates that when there are a large number of restrictions, the relevant constraints are difficult to satisfy. Many of the points in Figure 4 are clustered near zero, but the traffic at these locations is still 3.5, without a significant increase. Therefore, it is of great significance to conduct further research on genetic algorithm with equality constraint.

3.4 Multi-objective optimization model

Therefore, this paper once again proposes a specific solution for such patterns. Since the minimum residence time of vehicles at each intersection is 0, the smallest one is obtained by adding all the phases. Therefore, this paper divides an optimization objective into two parts. The calculation formula is as

$$\text{follows:}\begin{cases} \max(\sum_{i=j}^{m} a_i+\sum_{j=1}^{m} a_j) \\ \min(\sum_{i=1,j=1}^{mn} S_{ij}) \\ d_1\le t_{ij}^{e},t_{ij}^{r}\le d_2 \\ a_i \cdot T_{ij}\le C_{ij}^{l},b_j \cdot T_{ij}\le C_{ij}^{2} \end{cases} \tag{2}$$

If you do not know the constraints of the minimum algorithm, you can square it and add it to find the minimum, is: $\min\sum_{i=1,j-1}^{mn} S_{ij}^{2}$. Therefore, this paper uses the method of multi-objective optimal solution to find the optimal solution of the model.

3.4.1 Process of algorithm

This paper uses an adaptive genetic algorithm that includes a hybrid pattern of queues and niches [2]. The queuing theory is adopted because of the differences in the number of vehicles and traffic units, so it is difficult to unify them to reflect the adaptability of the group. In multi-objective optimization, the research needs to get Pareto solutions of average distribution as far as possible, so that decision makers can decide which value should be adopted in reality according to their own experience. An adaptive function is used to prevent local convergence in the algorithm.

3.4.2 Queue selection

The basic idea of queue selection is to sort the individuals in the group according to the individuals of the optimal Pareto solution, and then select the individuals according to the queue order. Therefore, the earliest Pareto optimization scheme will have a greater chance of being passed on to the next generation. After repeated several times, the Pareto optimal solution of the multi-objective optimal problem can be obtained. In the above model, traffic and delay are numbered according to their sizes, and sorted to obtain their degree of adaptation. This solves the adaptability problem caused by differences in flow and time units.

3.4.3 A niche

When solving multi-objective optimal problems, the obtained solutions are usually required to be distributed as far as possible in the global optimal solution, rather than limited to a small range of its optimal solution. In order to meet this demand, this paper adopts niche genetic algorithm. This method applies the concept of shared function to genetic algorithm for multi-objective optimization problems. This method can obtain more optimal results by constraining the number of the same or similar individuals. By comparing the first individual with other individuals, the following calculation formula is finally obtained:

$$\delta_{share}(x,y)=\begin{cases} 0 & \sigma(x,y)\ge\sigma_{share} \\ 1-\sigma(x,y)/\sigma_{share} & \sigma(x,y)<\sigma_{share} \end{cases} \tag{3}$$

In the formula $\sigma_{share}(x,y)$ is the share of each individual. $\sigma(x,y)$ is seen as an individual European example.σ_{share} is the relevant distance data. And through the following sharing function, a small part of the group can be punished, thus reducing the adaptability of the group.

$$f'(x)=\frac{f(x)}{\sum_{i=1}^{n}\delta_{share(x,y)}} \tag{4}$$

In this formula f(x), f'(x) is the fitness of individual x before and after applying the shared function. n is the size of the group and y is the individual that is different from x. After the calculation of the

niche data of each individual, it can improve the selection probability of individuals with smaller niche data, and can inherit to the next generation of individual groups, so that individuals with limited similarity can be better inherited by the next generation of individuals, and improve the diversity of related groups.

3.4.4 The fitness function of automatic adaptation

When the genetic algorithm is used to solve the optimization model, the selection method of fitness function[3] directly determines whether the convergence can be reached to the optimal solution. In this paper, we give an adaptive function of a specific model with equality constraints.Set the fitness function in equation (1) as $f(\vec{X})$, In formula (2), set as $g(\vec{X})$. The value for each population is $\vec{X}=(x_1,x_2\ldots x_n)'$, $f(\vec{X})$ and $g(\vec{X})$ they're all ethnic numbers.On this basis, the overall adaptability function of the multi-objective optimization model is $f(\vec{X})+t \cdot g(\vec{X})$. t here for function $g(\vec{X})$. During the iteration of the algorithm, t will change with the actual situation. Since formula (2) in this paper is to be equal to 0, or at least very close to 0, the minimum number of equation (2) should be counted.In other words $\min(\vec{X})$ is zero or is there a range where the minimum value of the population X is less than a constant, and once the range is exceeded, the weight is immediately increased, thus forcing the constraint of the relevant formula to be satisfied.

3.4.5 Specific algorithm

The specific algorithm is shown in Figure 5 below:

Note 1: First the group is introduced into equation (6.2) and the larger number of the function is used to calculate its function value. The minimum is 1, then 2, all the way to n; Next, the group is introduced into 6.3 and its function value is calculated. Different from Equation (6.2) here, equation (6.2) is the minimum value. Therefore, when queuing, the maximum function value is 1. The second number is 2, all the way to n. The results of its cohort are introduced into the fitness function described in 3.4.4 and classified as the fitness value of the population.

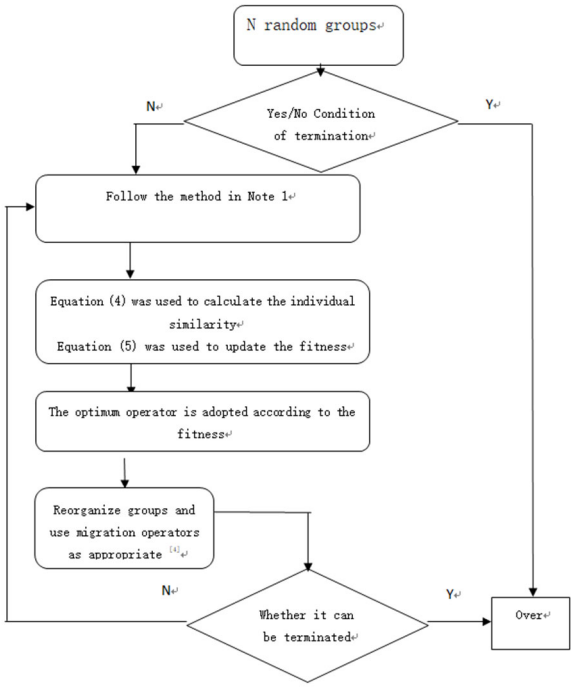


Fig. 5 Algorithm flow

3.5 Experiment of algorithm

In this paper, the adaptability function is a+t • b,aIs the queue position in the traffic flow function, b is the queue in the stay function, and t is the weight. Following this pattern, this article needs to be

set $\min(\vec{X})\leq 1$, t=3; when $n(\vec{X})\leq 3$, t=6; other t=12. Because the model has multiple peaks, it is easy to lead to premature algorithm maturity. Therefore, in this paper, migration operations are added in the 100th generation and the 250th generation, and migration operations are added in the generation. The results obtained are shown in Figure 6.

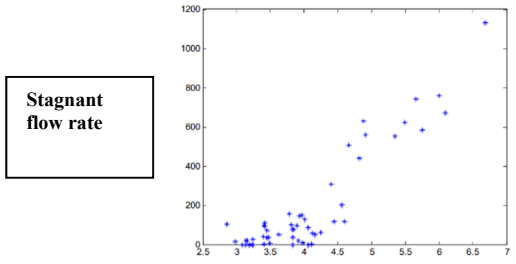


Fig. 6 Improved algorithm

The abscissa is the total traffic flow of each road, and the ordinate is the total residence time of each intersection. As shown in Figure 4, in general, the amount of retention increases with the increase of traffic. This article will calculate the average volume of traffic, therefore, the maximum amount of traffic is required, and the total residence time is exactly zero, or very close to zero. Therefore, as shown in Figure 4, the optimal flow rate of the whole transportation system is 4.113 vehicles /s/s, while the residence time is 0.1690. The average flow of each section is 0.5851, 0.7278, 0.6872, 0.7500, 0.6519, 0.7108. As an alternative, an optimal flow rate of 4.0591 vehicles per second and 0 dwell times can also be selected. The results show that this method can effectively solve problems containing the optimal model of the equation [5].

4. Conclusion

The focus of this thesis is to study the traffic flow control problem. On this basis, the average flow of each section is analyzed, and the optimal flow of each section is obtained. When a large model is processed, there will be a lot of equation constraints. In this paper, a problem is transformed into a multi-objective optimal model to make it non-negative. The algorithm first sorts the generated populations, and then uses the crowding mechanism of niche to iterate the genetic populations for many times to get multiple Pareto solutions. Finally, the scheme with maximum flow and maximum residence time as 0 is selected. Good results are obtained through simulation test.

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