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Research on Urban Traffic Control Method Based on Mobile Travel Data

Ziqing Li; Shenglei Pei

School of physics and electronic information engineering Qinghai University for Nationalities QingHai Xinin, China.

Abstract

The traffic congestion in big cities has become the latest issue that urgently needs people to solve, and congestion at intersections is an important cause of urban traffic congestion. With the popularity of vehicle-mounted GPS, large-scale, high-quality traUrban traffic control based on mobile travel datajectory data provides a new idea for urban traffic control. For a large amount of DiDi trajectory data, this paper studies a traffic signal timing optimization method based on genetic algorithm and genetic neural network. First of all, the trajectory data pre-processing work was carried out to obtain the traffic volume of the intersections. Secondly, the intersection simulation model based on Vissim software designed in this paper provides data input and result verification for the optimization method of timing plan. The simulation results show that the timing optimization method based on genetic algorithm and the timing optimization method based on genetic neural algorithm all can effectively alleviate the congestion at the intersection.

Keywords

Intelligent traffic signals; Trajectory Simulation; Timing optimization; Genetic Algorithm; BP Neural Networks.

1. Introduction

In the progress of social economy and the acceleration of urbanization, urban traffic has become the support of social and economic development Column. Although urban traffic plays a more and more important role in the process of urbanization, traffic congestion has gradually become a perplexing problem in the world Important problems of major cities [1]. Therefore, the ecological and socio-economic significance of solving the traffic congestion problem is more clear, which has become the consensus of the current society [2]. Among them, the complicated traffic problems of intersections in the traffic network of big cities, It has been the research focus of solving the problem of urban congestion at home and abroad [3]. However, the traditional timing control method is adopted in most urban intersections in China. The traditional traffic signal control system is to phase the signals in each direction of each intersection the timer is set to the same fixed time, which leads to the old signal cycle under the condition of great difference in traffic flow, which seriously reduces the traffic efficiency of the intersection and causes more serious traffic congestion.

In this paper, the traditional timing method of intersection traffic controller is improved. The optimization method of traffic controller phase timing based on genetic method and genetic neural network is studied. A simple intersection simulation model based on VISSIM software is designed to obtain the necessary data and evaluate the optimization results. Finally, the simulation results with reference value are obtained.

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2. Overview of Genetic Neural Network and Simulation Method based on VISSIM

2.1 Overview of genetic neural network

Genetic algorithm is an evolutionary algorithm applied in the field of computational mathematics to solve the optimization search problem [4]. The basic idea of genetic algorithm is to simulate the natural genetic mechanism and biological evolution theory, so as to search the optimal solution in the process [5].The implementation mechanism of genetic algorithm is to promote quantitative candidate (initial population) for an optimal solution problem through computer simulation abstract representation evolves under certain constraints (fitness function).

Artificial neural networks (ANN) originated from the information transmission mechanism of neurons in biology. A large number of neurons are interconnected to form a brain neural network in which information is transmitted and calculated to generate intelligence [6]. The neural network is composed of multi-layer neural layers, which can complete unsupervised learning, input unlabeled data, and complete automatic self-improvement and update through back-to-back propagation.

In the face of complex nonlinear system problems, the fitness function of genetic algorithm depends on the designer's experience it is easy to produce the problems of slow convergence speed and inaccurate results by repeated experiments in the test sum sample space in theory, any nonlinear system can be mapped and the global optimal effect can be obtained[7]. The genetic neural network system designed in this paper and the self-learning neural network improve the fitness function of genetic algorithm, which is the basis of genetic algorithm timing optimization.

2.2 Overview of simulation methods based on VISSIM

To create intersection model in VISSIM software, we need to complete the road network design, traffic flow input, signal lamp design and placement, data acquisition points and evaluation parameters settings. The function of the simulation model in this paper is to simulate the queue length of each effective road section according to the traffic flow information obtained by data preprocessing, as the optimization objective of the next algorithm.

The creation of basic road network is the basic step of intersection simulation, in which the links need to be connected to simulate one a simple road network. The intersection model of this simulation model defines eight sections, which are two-way north-south straight, north-south left turn, east-west direction straight, east-west direction left turn. The design of road includes the design of section number, length and other parameters set.

The setting of vehicles includes the proportion of vehicle composition and the change of vehicle acceleration. The input of traffic flow refers to placing a predetermined number of vehicles in the designated road section. In the creation of traffic lights, the signal is created according to the number of phases of each intersection control Model No. In the traffic controller model, the traffic light phase and time length are designed according to the number of original phases and the length of original phases. After creating the traffic controller model, the traffic light phases are set in the corresponding sections to realize the traffic light control of the intersection. The setting position of street lamp is set at the left corner of the vehicle, and the position of straight line and left turn is parallel to achieve the best simulation effect.

The queue length is counted from the placement point of the queue counter in the link, and the average queue can be obtained after the simulation the evaluation report of the team leader and the maximum queue length. Queue length is the main input data for data optimization using genetic algorithm and genetic neural network for data fitting and optimization.

3. Traffic Light Control Method based on Genetic Neural Network

In the traffic light control method based on genetic neural network, the nonlinear relationship between queue length, traffic flow and green light duration obtained by BP neural network is used as the fitness

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function of individuals in genetic algorithm. Then, based on genetic algorithm the optimization of the population is completed, that is to search for the green light duration with the minimum queue length under the given traffic flow.

3.1 Genetic algorithm

In the traffic light configuration of the intersection, one turn often appears in two phases at the same time, for example, the southbound left turn section appears in the first phase and the second phase of the traffic light controller at the same time. In order to solve this problem, this paper uses the optimization method of genetic algorithm to optimize the road section rather than the phase. According to the traffic flow and queue length of a certain road section, genetic algorithm is adopted the algorithm optimizes the green light duration of a road section by genetic algorithm, and obtains the optimal green light duration of a certain road section under the limited conditions. After rounding off the optimal green light duration of the road section, the whole phase duration of the intersection is calculated according to the phase of the section. The pseudo code of genetic method in this paper is shown in Figure 1.

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Algorithm 3-1 genetic algorithm

Input:          intersection queue length, traffic flow, signal length constraints
Output:         signal light duration of each section of intersection
Initialization: initialization crossover probability Pc, mutation probability Pm, population size M, termination evolution
                algebra G, fitness function Ft and other parameters
                Random generation of PoP
1:              The fitness function value Ft(i) of all individuals in Pop was calculated
2:              Initializing the empty population newPoP
3:              According to the fitness function value, the quantitative individuals were selected from the population
                pop by roulette method
4:              if      random(0,1)<Pc
5:              Then performs the crossover operation on two individuals according to the crossover probability Pc
6:              if      random(0,1)<Pm
7:              Then performs mutation operation on two individuals according to the mutation probability Pm
8:              Two new individuals were put into the population newPoP
9:              if the number of new individuals is less than M
10:                     goto step 3
11:             newPoP replaces PoP
12:             if evolution algebra is less than G
13:                     goto step 1
14:             end if
```

Fig. 1 Pseudocode of the Genetic algorithm

3.2 Genetic neural network method

Genetic algorithm for data optimization needs to design a fitness function that can accurately describe the relationship between the advantages and disadvantages of the population, so the designer needs to master the relationship between the input data in advance, which requires the designer to master the relevant knowledge in other fields. This section uses neural network can complete the nonlinear fitting of unknown relationship data without supervision, which solves the problem of fitness function setting in genetic algorithm in the previous section.

The nonlinear relationship among queue length, traffic flow and green light duration obtained from BP neural network is used as the fitness function of individuals in genetics. Then, the population optimization is completed based on genetic algorithm, that is, under the given traffic flow, the green light duration satisfying the minimum queue length is searched. The pseudo code of this genetic neural network method is shown in Figure 2.

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Algorithm 4-2 optimal timing method based on Genetic Neural Network

Input:          training set X, neural network design parameters, genetic algorithm design parameters, I intersection
                traffic flow ri, timing constraints ft
Output:         i intersection section signal light timing Ti
Initialization:  initialization of neural network network weight and neuron value
                The parameters such as crossover probability PC, mutation probability Pm, population size m, termination
                evolution algebra g, fitness function ft, etc;
                Random generation of PoP
1:               Neural network training
2:              The weight table of each section of intersection is calculated according to the proportion of traffic flow
3:              Through neural network network fitting, the queue length y of each road section is obtained
4:              The fitness function values of all individuals in the population pop were calculated
5:              Initialization of air group newPoP
6:              According to the fitness function value, the quantitative individuals were selected from the population
                pop by roulette method
7:              Cross operation was carried out according to the cross rate Pc
8:              The mutation operation is performed according to the mutation rate Pm
9:              Update population newPoP
10:             if The number of newPoP individuals is less than the population size M
11:                     goto step 6
12:             Newpop replaces PoP
13:             if Evolution algebra is smaller than termination evolution algebra G
14:                     goto step 4
15:             end if
```

Fig. 2 Pseudocode of the Genetic neural network algorithm

4. Algorithm Implementation

The data used for the algorithm analysis in this paper comes from didi trip. Didi travel, as a leading mobile travel platform in China, has a large number of taxi track data. With the rapid development of data mining technology, it is not difficult to mine refined effective information from massive data.

4.1 Data preprocessing

The massive data contains many missing, inconsistent and abnormal values, and the original data does not conform to the format required for the next operation, therefore, data preprocessing is needed. In this paper, the genetic neural network based time allocation optimization method needs the road traffic volume, the road section queue length and the initial phase time length as the data input, so it is necessary to carry out the corresponding preprocessing and simulation work for Didi vehicle trajectory data. According to the initial desensitization trajectory data, this data preprocessing scheme obtains the number of traffic flow of each intersection and phase in each date. The program flow chart is shown in Figure 3.

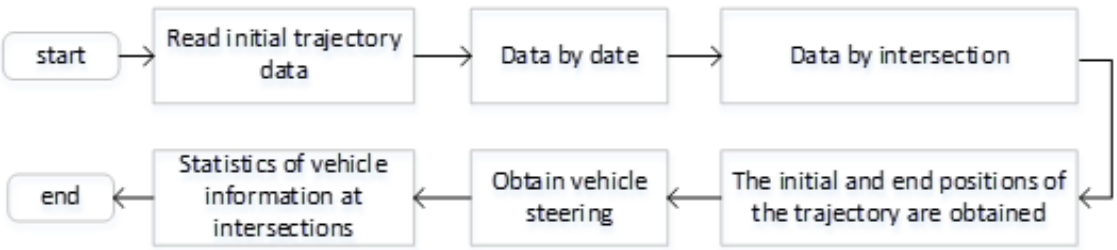

Fig. 3Flow chart of data preprocessing

4.2 Experiment of traffic signal control method based on Genetic Neural Network

The nonlinear relationship among traffic flow, green light duration (input) and queue length (output) is obtained by neural network fitting. The nonlinear relationship is used as the fitness function of genetic algorithm, and the genetic optimization is used to obtain each intersection the optimal green time of each section. Then, the optimal green time obtained from genetic neural network is calculated,

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and the standard phase time of intersection signal controller is obtained. Finally, five optimal signal timing schemes based on genetic neural network are obtained.

The green light duration of each phase of intersection is optimized by genetic neural network method, which is updated in VISSIM simulation intersection the queue length of each phase of the intersection is obtained by simulation. Because of intercourse in this section, the queue length of the main section (with the largest traffic flow) is used as the evaluation index of the optimization results. Finally, the queue length of the main sections of five intersections before and after optimization by genetic neural network algorithm is compared (unit: vehicle) As shown in Table 1.

Tab. 1 Optimization effect of genetic neural network

	cross1	Cross2	Cross3	Cross4
Before optimization	162	154	128	128
After optimization	54	38	43	26
Optimization effect	66.7%	75.3%	66.4%	79.7%
Average optimization effect	67.56%			

After optimizing the phase length of the intersection by genetic algorithm, the average reduction of the queue length is 67.56% (average value) of the original queue length. At the same time, the intersection optimized by genetic algorithm and genetic neural network is compared in Table 2 the optimization effect of signal timing scheme. It can be clearly seen from the table that the optimization method of intersection timing based on genetic neural network the case has better optimization effect.

Tab. 2 Comparison of optimization effects of two methods under the same intersection

method	cross1	cross2	cross3	cross4	average
genetic algorithm	66.4%	66.9%	50.8%	58.6%	56.54%
Genetic neural network	66.7%	75.3%	66.4%	79.7%	67.56%

5. Conclusion

In this paper, the desensitization data provided by didi is processed based on genetic algorithm and genetic neural network. The purpose of this paper is to obtain the optimal intersection timing scheme which can greatly reduce the length of intersection queue and reduce traffic congestion. In addition, genetic algorithm is used in this paper before the optimization of time allocation by GA-NN and GA-NN, the traffic trajectory is preprocessed. The simple simulation of intersection is carried out by VISSIM software, which solves the problems of too small traffic flow and difficult to obtain queue length.

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