Parameter Correction of VISSIM Multi-intersection Simulation Model Based on Combined Genetic Algorithm

Jing Zhang¹, Lin Zhang¹ and Changwei Wang²*

1 College of Civil and Architectural Engineering, North China University of Science and Technology, Tangshan, Hebei, 063210, China
2 College of Electrical Engineering, North China University of Science and Technology, Tangshan, Hebei, 063210, China
*Corresponding author’s e-mail: 809327010@qq.com

Abstract. In the field of traffic simulation research, the requirements of microscopic traffic simulation model accuracy and intersection popularity are getting higher and higher. Aiming at the shortcomings of traditional genetic algorithm, such as slow speed, huge time-consuming and easy to fall into local optimum, a parameter correction algorithm for VISSIM simulation model based on combined genetic algorithm is proposed in this paper. Neural network is used to predict and analyze, and genetic algorithm with partitioning operator is used to correct the parameters, and the error of simulation delay and measured delay is designed as the objective function. Finally, taking three typical continuous intersections of a main line as an example, a microscopic traffic simulation model is established and the parameters are corrected. It is showed by the results that the corrected error is as low as 9.63%, which proves that the proposed method is feasible and robust.

1. Introduction
Microscopic traffic simulation can reproduce the urban road traffic conditions. The accuracy of the simulation model is of great significance to the design of traffic control schemes and traffic control. However, the traffic model simulation operation result under the default parameter setting is quite different from the actual survey data, which can not represent the simulated actual road traffic conditions. To solve this problem, a large number of research results have been obtained in the field of correction of traffic simulation models at home and abroad. Many algorithms such as orthogonal test method[1], genetic algorithm[2] and SPSA algorithm[3] have been used to correct traffic. The simulation model was designed and the corresponding model correction process was designed, which achieved good results. However, there are still some shortcomings in the research of model parameter correction, such as the inefficiency of the optimization speed and accuracy of the correction algorithm, and the improvement and selection of the algorithm are still in the preliminary study. Therefore, it is necessary to use the computer to adopt new technology to realize the automatic correction of the parameters of the intersection microscopic traffic model, so that the calibration value of the microscopic traffic simulation parameters can be close to the actual traffic situation in the local area.

In this paper, the VISSIM microscopic traffic simulation software correction method is studied. The neural network and segmentation operator are integrated into the traditional genetic algorithm. The traffic simulation model parameter correction process of genetic algorithm is designed. The joint development of VB and VISSIM is selected to establish a complete and practical parameter.
calibration method is implemented, and the micro-traffic simulation parameters of three continuous intersections are corrected. The feasibility and robustness of this parameter correction method are proved by analyzing the magnitude of the delay error.

2. VISSIM simulation model parameter correction

2.1. Traffic simulation model parameter selection
In the calibration of traffic simulation model parameters, the driver behavior parameters play a key role in the accuracy of the simulation results. According to the sensitivity of road network capacity and vehicle performance to various parameters, five key driving behavior parameters are selected: minimum front vehicle distance, maximum deceleration, average parking distance, additional part of safety distance and multiple of safety distance.

2.2. Target function setting
Delay is an important evaluation index of traffic operation. In this paper, the error of the average total delay of each vehicle passing through the intersection is used as an index to evaluate the calibration parameters of the traffic simulation model. The objective of parameter calibration is to minimize the delay error between the operation of the calibrated micro-traffic simulation model and the actual acquisition[4]. The objective function expression is as shown in equation (1):

$$E = \frac{1}{n} \sum_{i=1}^{n} \frac{|D_{ri} - D_{si}|}{D_{ri}}$$

Where: $D_{ri}$ is the average delay of the actual survey of the ith intersection; $D_{si}$ is the delay of the ith of the ith intersection of the VISSIM simulation output; n is the number of intersections.

2.3. Fusion genetic algorithm analysis

2.3.1. Network structure of generalized neural networks
Aiming at the time-consuming problem of genetic algorithm, a trained generalized regression neural network to simulate the output of VISSIM is presented in this paper, which is to say that the optimization results of each iteration of genetic algorithm are directly used as input factors of neural network, and the trained generalized regression neural network is used to predict the output of VISSIM simulation results, so as to improve the efficiency of parameter correction. Its network structure [5] is as follows:

![Generalized Regression Neural Network Network Structure Diagram](image)

Fig.1 Generalized Regression Neural Network Network Structure Diagram Generalized Regression Neural Network Network Structure
The generalized regression neural network consists of four layers, including a pattern layer, an input layer, a summation layer, and an output layer.

The number of pattern layer neurons is the same as the number of training templates. Each neuron corresponds to the set of training. The transfer function usually uses a Gaussian function, as shown in equation (2):

\[ p_i = \exp \left( -\frac{(x-x_i)^T(x-x_i)}{2\sigma^2} \right) \quad (i = 1, 2, ..., n) \]  

Where \( X \) is the input variable, \( X_i \) is the learning sample corresponding to each unit, \( \sigma \) is the width coefficient of the Gaussian function, and the mean square value (MSE) of the error is used as the evaluation index to determine the width coefficient.

The summation layer is composed of the arithmetic summation and the weighted summation calculation of the output of the mode layer neurons by two types of neurons, and the calculation formulas are respectively (3) and (4).

\[ S_D = \sum_{i=1}^{n} \exp \left( -\frac{(x-x_i)^T(x-x_i)}{2\sigma^2} \right) \]  
\[ S_{Nj} = \sum_{i=1}^{n} Y_{ij} \exp \left( -\frac{(x-x_i)^T(x-x_i)}{2\sigma^2} \right) \quad (j = 1, 2, ..., m) \]

The number of neurons in the output layer is equal to the dimension \( m \) of the output vector in the learning sample, which is obtained by dividing the two types of summation results obtained by the summation layer, as shown in equation (5).

\[ Y_j = \frac{S_{Nj}}{S_D} \]  

2.3.2. Split operator

The traditional genetic algorithm is easy to fall into local optimum when solving, which reduces the precision of optimization. The introduction of segmentation operators to find the local best search position is studied in this paper. The basic idea is that two local optimal individuals will tend to solve the same "concave" of space, and thus, there is a potentially better genetic position between the genes of the two locally optimal individuals. The calculation principle of its local optimization is shown in Figure 2. M and N are two adjacent optimal individuals, O and O' are the most advantageous positions obtained by the golden ratio, and the relationship between MO and MN, O'O and O'N satisfies the definition of the division point of the golden ratio.

![Fig.2 The illustration of ratio based local optimal sets](image)

\[ \frac{|MO|}{|MN|} = \frac{|O'O|}{|O'N|} = 0.618 \]

2.3.3. Fusion genetic algorithm process design

The flow of parameter correction of VISSIM model based on fusion genetic algorithm is shown in Fig. 3. In the whole process, the intersection delay error of road network model is taken as the objective function, and the output value of VISSIM simulation software is predicted by trained neural network, so as to replace the operation of simulation software, and the segmentation operator is introduced into genetic algorithm for local optimization, thus improving the speed and accuracy of parameter correction. The main steps are as follows:

(1) The output values of VISSIM simulation results under the influence of different parameter combinations are collected, and a data set is established, which is used to train the generalized regression neural network.

(2) Initialization. The genetic algorithm and the control parameters of the segmentation operator are initialized to generate a global optimization initial population PA and a local optimization initial population PB, and the initial populations are different from each other. Set evolutionary algebra
Gen=90, PA population size Na=50, segmentation operator optimization scale m=10, PB subpopulation size Nb=2 m; objective function E error is ρ.

(3) For individuals with new parameters in population PA and PB, the VISSIM simulation function is called by COM interface to run a simulation. The new parameter combination generated after each iteration and traffic data are used as input parameters of the trained generalized regression neural network. The output value of VISSIM simulation under this parameter combination is predicted by the neural network, and the predicted result is participated in the calculation of fitness function value.

(4) The judgment of algorithm termination. If the fitness value satisfies the convergence condition or the number of iterations reaches the preset maximum, the optimal model parameters are output, and then the next step is taken.

(5) Metropolis criterion is used to probability accept new individuals of local optimization population PB, and excellent individuals are used to replace the worst individuals of population PA in turn.

(6) Local optimization operation [6]: In order to maintain the diversity of the population, in each new generation PA of the simple GA algorithm, the best 2 m individual update subpopulations PB are selected, and m is randomly selected from the PB. As an initial vector, a good individual is called the partial optimization search of the segmentation operator to strengthen the genetic algorithm, and the local optimal population PB is updated.

(7) Genetic operator operation [7]: Globally optimize the population PA by using the “select, cross and mutation” operator, and go to step 3.

3. Case Analysis

3.1. Case description
Chegongzhuang Avenue is the main urban road from east to west with a total length of about 1.88 km (from Sanlihe Road in the West and from the east to the second ring in the west). In the whole urban road network of Beijing, there are comprehensive traffic types in Chegongzhuang Avenue, and the traffic characteristics are representative. The sketch of the current situation of the main intersections is shown in Figure 4. (Subsequently, A, B and C are used to denote the names of the following three intersections)
3.2. experimental design
Three consecutive intersections (A, B, C) of Chegongzhuang Street in Beijing were selected as simulation verification objects, and static and dynamic data of traffic at each intersection were collected to pave the way for subsequent traffic simulation modeling.

Design 1: Use VISSIM to establish road network model, input current traffic data, and run simulation with default parameters. The simulation results show the delay of all intersections. The delay error $E$ is calculated by using the above objective function expression.

Design 2: The traditional genetic algorithm is used to correct the traffic simulation parameters of the selected five parameters in the experimental object, and record the formation time and objective function value of the model output before and after the parameter correction.

Design 3: Five parameters in design 2 are calibrated by the calibration algorithm proposed in this paper. Formation time and objective function values of model output before and after calibration are also recorded. The feasibility and robustness of the improved algorithm are verified by comparing with design 1 and 2.

3.3. Result analysis
The parameter correction result and the objective function comparison table obtained by running simulation and parameter correction are shown in Table 1 and Table 2.

![Fig. 4 The sketch map of the main intersection of Chegongzhuang Street](image)

| parameter name                        | unit | Ranges | Defaults | Genetic algorithm correction | Algorithm correction in this paper |
|---------------------------------------|------|--------|----------|-----------------------------|-----------------------------------|
| minimum headway (front/rear)(MinHF)   | m    | [0.5,1]| 0.5      | 0.34                        | 0.30                              |
| maximum deceleration(MaxDC)           | m/s² | [-6,-4]| -4.0     | -3.01                       | -2.56                             |
| average standstill distance(AvgSD)     | m    | [1,3]  | 2.0      | 1.49                        | 1.36                              |
| additive part of safety distance(AddSD)| m   | [1,5]  | 2.0      | 1.88                        | 1.82                              |
| multiple part of safety distance(MulSD)| m   | [1,6]  | 3.0      | 3.36                        | 3.42                              |
Table 2 . Object function comparison

| Car delay (s) | Intersection | Objective function calculation (%) | Parameter correction formation time (s) |
|---------------|--------------|------------------------------------|----------------------------------------|
| Actual investigation | A 91   | B 87   | C 82   | 0     | 0     |
| Default parameter |            |        |        |       |       |
| Genetic algorithm |            |        |        |       |       |
| Algorithm |            |        |        |       |       |

Through the comparative analysis of the above table, it can be seen that the simulation platform of the main intersection of Chegongzhuang Street can effectively improve the simulation accuracy and speed by using the proposed fusion genetic algorithm, and control the average delay error of vehicles at the intersection within 10%, which verifies the effectiveness and robustness of the design method.

4. Conclusions

In this paper, the parameter calibration process of VISSIM simulation model based on generalized regression neural network, segmentation operator and traditional genetic algorithm fusion improved algorithm is designed. Taking three main intersections of Chegongzhuang Street as examples, according to the actual data collected, default parameters, traditional genetic algorithm and genetic algorithm are used respectively. Five key parameters were corrected by the method. Through comparative analysis, the results show that the simulation model calibrated by the proposed correction algorithm can better describe the actual traffic situation and improve the speed of parameter correction.

Acknowledgments

The work described in this paper was fully supported by a grant from Supported by the National Natural Fund (No. 51378171) and the Graduate Student Innovation Fund of North China University of Science and Technology (No. 2018S27 ).

References

[1] YU Quan, WAND Xiaomeng, DENU Xiaohui. Simulation parameter calibration of single signalized intersection based on orthogonal experiment method[J].Highway and Transportation Research and Development,2012,29(S):57-62. (in Chinese)
[2] LI Zhiming, YAN Xiaoyong. Study on correction method of traffic simulation model based on genetic algorithm[J].Communication Standardization, 2006(4); 21-23. ( in Chinese)
[3] ZHANG Yu, YU Lei, ZHAO Nale, et al. Application of simultaneous perturbation stochastic approximation algorithm in parameter calibration of Vissim microscope simulation model[J]. Journal of Transportation Systems Engineering and information Technology, 2010,10(4):44-49. (in Chinese)
[4] LI Zhenlong, WANG Baoju, JIN Xue, et al. Parameter Calibration Method for Vissim Simulation Model of Main and Auxiliary Roads[J]. Journal of Traffic Information and Safety, 2015(2): 45-50. (in Chinese)
[5] Tang Ze. Research on parameter correction technology of VISSIM traffic simulation model [D]. Jilin University. (in Chinese)
[6] Yang Wenchen, Zhang Lun, Wang Wei, et al. Parameter Correction of VISSIM Simulation Model Based on Golden Section Genetic Algorithm[J]. Journal of East China Jiaotong University, 2017(3). (in Chinese)
[7] He Zhaocheng. Real-time Optimal Control and Simulation of Traffic Signals at Urban Single Intersection[J]. journal6, 2006, 46(33):239-243. (in Chinese)