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CALIBRATION OF VISSIM FOR SHANGHAI EXPRESSWAY USING GENETIC ALGORITHM

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ABSTRACT

This paper presents how an optimal optimization method, Genetic Algorithm (GA), is applied for finding a suitable combination of VISSIM parameters. The North-South (N-S) Expressway is investigated and simulated in VISSIM platform using field data obtained from Traffic Information Collecting System (TICS) in Shanghai. Numerous simulation tests indicate that the following main parameters have affected simulation precision most deeply, such as Desired Speed in Reduced Speed Area (DSRSA), Desired Lane-Change Distance (DLCD), and Wiedemann99 car-following parameters, the average desired distance between stopped cars (CC0), the headway time (in second) that a driver wants to keep at a certain speed (CC1), and safety distance a driver allows before he intentionally moves closer to the car in front (CC2). The prepositional parameter combination of DSRSA, DLCD, CC0, CC1 and CC2 is 40,500, 1.5, 0.8 and 3.50 for peak time traffic.

1 INTRODUCTION

Recently, with more and more urban expressways have sprung up in many cities of China, expressways are proved to be more effective to solve traffic problems. At present, there are three basic methods to research into expressway-related problems: regression analysis, empirical model and simulation model (Chen et al, 2000). With the progress of computer science and technology, more and more field simulation model applications appear in other countries. Roger and Sutti (2003) utilized VISSIM and PARAMICS worked on a suburban interchange. Prevedrouros, P.D. and Y.wang (1999) used CORSIM, INTEGRATION and WATSim accomplished a large freeway/arterial network. Alexander Skabardonis (2002) worked on weaving sections in California using simulation model.

VISSIM is a microscopic, time-stepping, stochastic simulation model for traffic system operation analysis. (VISSIM Version 3.7 Manual, 2003). An overall system model consists of a set of cross-linked sub-models that depend on a large of parameters to describe traffic control operation, traffic flow characteristics, and drivers' behaviors. These models contain default values for each variable, but they also allow users to input a range of values for the parameters. As there may exist huge difference of road status, traffic demand and driver behavior between china and other developed countries, most of the simulation parameters which have been determined based on other different traffic situations before do not suit for that of china. It needs to recalibrate system parameters of VISSIM to simulate expressway traffic operation in Shanghai. Optimization of VISSIM model performance involves the selection of the "best" set of values for the parameters. But few researches on expressway has been conducted in china (Chen et al, 2000). With the recent growth in computational resources and plentiful Intelligent Transportation Systems (ITS) data, there are more opportunities to develop an automatic calibration methodology for traffic micro-simulation models based on optimization theory. In recent years sequential simplex algorithm (Kim, K, 2003), simulated annealing algorithm have been studied by several researches.

In this paper, Genetic Algorithm is proposed as an appropriate technique for the calibration of traffic micro-simulation model. It has been widely used for optimizing systems containing factors (Goldberg 1989). The proposed approach will be illustrated and discussed on N-S expressway in Shanghai of China. This calibration focused on 24-s point-processing output of speed and volume at loop detectors stations within an 8.4-km-long segment. By reducing the simulation errors between VISSIM output and field data, a set of parameter values were found to fit the evening peak traffic characteristics.

2 SIMULATION OF N-S EXPRESSWAY

2.1 VISSIM Simulation Model

The simulation model, VISSIM, version 3.70, was used in this research. Essential to the accuracy of a traffic simulation model is the quality of the actual modeling of vehicles or the methodology of moving vehicles through the network. VISSIM uses the psychophysical driver behavior model developed by Wiedemann.

2.2 Test Bed

The N-S elevated expressway is chosen for the application of the model. The selected expressway segment is the North-South direction as the traffic artery in Shanghai. This site was selected because there are several overhead pedestrian bridges across the expressway, making video recording of traffic possible in the absence of loop detector. It belongs to the "shen-shape" expressway systems in Shanghai. We consider that this expressway can represent the typical traffic flow operating character in China. The VISSIM model of N-S Expressway is illustrated in Figure 1.

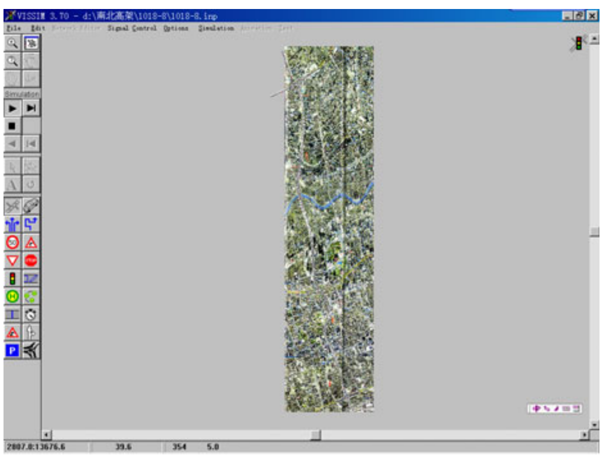

Figure1: The N-S Elevated Expressway VISSIM Model

2.3 Data Collection

Now ITS in shanghai is under construction. Through the ICICS (Inner City Information Collecting Systems) we can get the "Yan'an" elevated expressway real-time data including volume, speed, vehicle type, occupancy and headway for every lane at 20 seconds interval. We extracted one-week data for this research. Meanwhile we saved one day peak time video information about "N-S" elevated road, through the TJVICS (TongJi Video Information Collecting Systems) we also can get the necessary traffic information such as traffic volume, vehicle type, headway, speed etc, al (Sun, et al, 2004). For the reasons of model calibration and validation we got the N-S trip OD through manual traffic counts the license plate at on- and off-ramps. Table 1 and Table 2 are the OD trip of N-S elevated road on March, 4th.2004.

Table 1: Field OD Data of N-S Direction Ramps

Off / On	13	12	11	9	8	7	5	3	2	1
17	0	0	234	142	134	186	172	66	94	88
16	0	0	274	105	195	48	105	89	51	76
15	0	0	639	188	241	167	189	104	122	135
14	349	851	435	111	90	148	150	79	103	97
13	0	129	188	41	53	103	99	49	90	89
12	126	0	269	76	173	163	142	104	122	129
10	0	0	0	220	194	382	203	125	157	162
8	0	0	0	0	0	42	532	97	388	197
7	0	0	0	0	25	0	392	270	70	244
6	0	0	0	0	0	0	424	232	260	298
4	0	0	0	0	0	0	0	247	337	509

Table 2: Field OD Data of S-N Direction Ramps

Off / On	4	6	7	8	10	12	13	14	15	16
1	349	173	231	143	88	73	36	108	97	58
2	318	203	74	272	94	70	50	110	120	45
3	255	202	418	67	108	94	34	96	126	81
5	0	482	500	625	216	130	62	210	243	140
7	0	0	0	0	281	231	182	372	383	129
8	0	0	0	0	220	225	48	224	397	317
9	0	0	0	0	306	120	79	296	405	198
11	0	0	0	0	0	348	499	479	388	200
12	0	0	0	0	0	0	0	268	262	82
13	0	0	0	0	0	0	0	312	375	281

In the above two tables, the Number is the ramps' numbers, which are coded according to the local traffic management department.

3 VISSIM CALIBRATION PARAMETERS

The test site was coded into the VISSIM model, and then we selected the calibration parameters according to the characteristics of expressway traffic flow and practical experiences. The main parameters affecting simulation precision are Desired Speed in Reduced Speed Area (DSRSA), Desired Lane-Change Distance (DLCD), and Wiedemann99 car-following parameters, the average desired distance between stopped cars (CC0), the headway time (in second) that a driver wants to keep at a certain speed (CC1), and safety distance a driver allows before he intentionally moves closer to the car in front (CC2).

3.1 Calibration Procedure Using Genetic Algorithm

Genetic Algorithm is an extensively used search technique that inherits ideas from natural evolution to effectively find good solutions for combinational parametric optimization problems. GA has been applied for several transportation-engineering problems. Recent works can be found for bridge maintains planning (Liu et al.1997), pavement maintenance scheduling (Fwa et al.1996), traffic signals design (Chua et al.1995), and parameter calibration for PARAMICS (Lee, D., et al.2001).

Compared with other optimization methods, the value searching space is the whole value space in Genetic Algorithm, it doesn't use the value of variables but using the genetic code (0 or 1) as the variable value, the judging rule is not definite but stochastic, its basic idea is as follows (Gan Yingai et al. 1990).

Firstly, m gene seeds populations or m seeds were chosen stochastically in the searching space, then the object functions value of these seeds populations were calculated and compared, i.e. to evaluate the goodness or badness of the units; then two points were chosen stochastically from m points, and the better one was given higher weights while the worse one with lower weight. Finally, based on the two points, a new point was generated stochastically; the noise was added if necessary. Repeat this progress until m new points were generated. In other words, m new gene groups must be better than the parent ones, and the new points are much nearer to the optimum value.

The software that performed this calibration may be divided into three modules, the VISSIM, GA and control modules, respectively, as shown in Figure 2. The VISSIM module performed regular simulation runs based on the input parameters provided by the control module, through the VISSIM data input file. The control module is a program compiled in the Visual Basic language that provided data input and controlled the interaction between the VISSIM and GA modules.

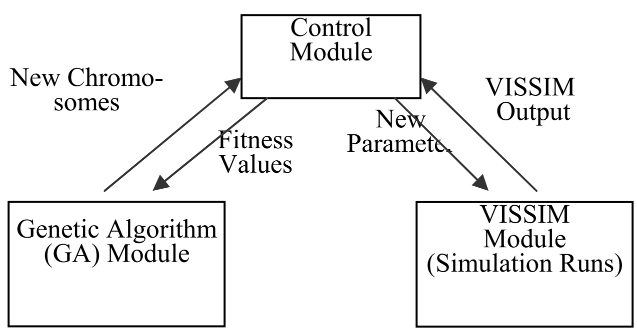

Figure2: Program Modules for VISSIM Calibration

3.2 Results and Discussions

All test sites were simulated using default parameters at peak and off-peak time. The prepositional parameter combination of DLCD, WTBD, CC0, CC1 and CC2 is 300,90,1.5,0.8 and 3.50 for peak time and 200,45, 1.5,1.0 and 5.0 for midday off-peak traffic. Limited to the paper size here we only selected the typical results.

Figure 3 shows the measured speeds, predicted speeds using default parameters and predicted speeds using the calibrated parameters from N-S expressway at off-peak time.

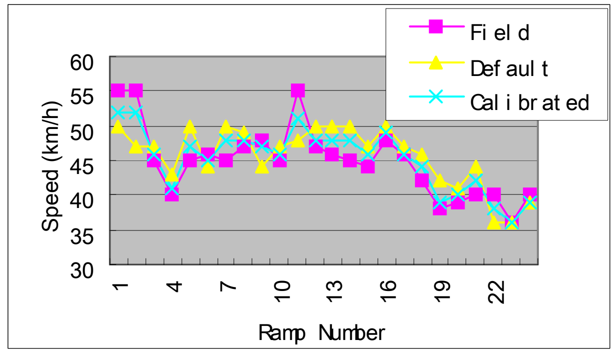

Figure 3: Three Kinds of Speeds from N-S Expressway at Off-peak Time

Figure 4 and Figure 5 show the measured, the predicted volumes using the default parameters and the predicted volumes using the calibrated parameters at eight sections from N-S and S-N expressways at peak time.

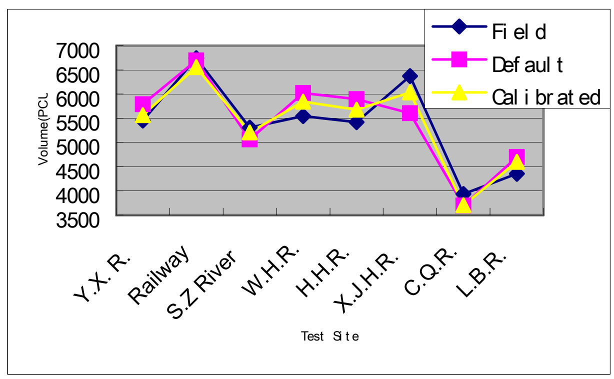

Figure4: Three Kinds of Volumes from N-S Expressway at Peak Time

From these figures we can find the VISSIM predicted average speeds are in close accordance with the field measurements. In Figure 3 the absolute average difference between measured and simulated speeds before calibration is 1.86 percent, with a Root Mean Square Error (RMSE) value of 3.88. While the absolute average difference between measured and simulated speeds after calibration is 0.84 percent, with a RMSE value of 2.09.

4 CONCLUSIONS

VISSIM was calibrated against field data collected through ICICS in Shanghai. The application of GA as a parameter optimization technique has been illustrated. Several important findings result from this calibration can be summarized as follows:

(1) The main parameters affecting simulation precision most deeply are DSRSA, DLCD, CC0, CC1 and CC2.

(2) The calibrated VISSIM model simulates and reasonably recurs observed traffic operations on the field road. Good accordance between measured and predicted values was obtained for all the combinations of design characteristics and traffic demand patterns.

(3) In general, the calibrated parameter values indicate that drivers in Shanghai are more aggressive in lane changing and car following compared with the default values in VISSIM.

(4) We need to put more efforts to study free-flow speed as in this research we used it as an artificial "speed limit" (it adjusted the overall operating speed in the traffic stream).

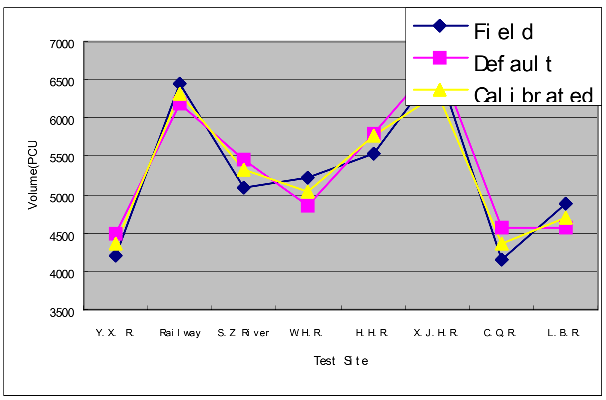

Figure 5: Three Kinds of Volumes from S-N Expressway at Peak Time

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