Analysis of Influencing Factors of Pedestrian-Vehicle Accident Reconstruction Based on Pc-Crash

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Keywords: accident simulation, pedestrian-vehicle accident, Pc-crash, orthogonal test.

Abstract. In this paper, 12 parameters of pedestrian-vehicle accident reconstruction in Software Pc-crash were analyzed and a model of pedestrian-vehicle collision was modeled. The distance between the last position of vehicle and pedestrian is used as evaluation index. The weights of 12 parameters were acquired by applying the orthogonal test. Through the analysis of influenced degree of parameters, the paper contributes to further study about reducing pedestrian-vehicle accident reconstruction error, and improving the efficiency of accident reconstruction.

Introduction

It has reported that nearly 200,000 traffic accidents occurred in 2013, of which more than 20% accidents are pedestrian-vehicle accidents [1]. Identification and analysis of these accidents requires a clear understanding of the impact of parameters on the results of the accident. This is generally studied through simulation using either dummy or computational models. Dummy test have a high reliability, but the experiment is inconvenient and cost is also expensive; in contrast, the computer simulation not only has high reliability, the test can also be adjusted according to the actual parameters of the model accident. Recently, pc-crash has been widely used in traffic accident simulation.

Many articles have been made to research pedestrian-vehicle accident. X.J.Liu et al used a 50th% male model in MADYMO to evaluate the influence of impact speed and vehicle front structure on the injury of pedestrian [2]. D. Otte used dummy model to evaluate the influence of impact speed r and mean deceleration on throw distances of pedestrian [3]. J.R. Elliott et al have made a research on the influence of vehicle speed, pedestrian speed gait on the accident [4].

Although the existing papers are mainly based on injury and throw distance, in the real collisions, a lot of parameters should be comprehensively considered, and some of parameters cannot be accurately obtained, such as braking distance of ABS automobiles and throw distance of pedestrian. Thus, in this paper, collisions were reconstructed in the Pc-crash, the final distance between vehicle and pedestrian (D) was used as evaluation index because it can be easily obtained, and weights of parameters were analyzed by orthogonal test. The main goal is to reduce the workload of data acquisition and improve precision of traffic accident reconstruction.

Parameter Selection

In order to improve the efficiency of data collection and selection, parameters of accident reconstruction need to be sorted into two categories according to the method of collection.

The first type is the exact parameters which can be easily and precisely measured or obtained by referring to manuals. However, in some accidents, these parameters cannot be obtained because of severely damaged, it should be considered. In this paper, it includes hood edge height (HEH), bumper bottom height (BBH), hood length (HL), human height (HH) and human weight (HW) (see Fig. 1).

The second type refers to estimation parameters which do not have high accuracy because of different selection and means of method includes empirical parameters and collection data. The following estimation parameters were considered: vehicle speed (V_v), impact angle (φ), impact position (P), pedestrian speed (V_p), friction coefficient between pedestrian and vehicle (f_{pv}), friction coefficient between pedestrian and ground (f_{pg}), friction coefficient between vehicle and ground(f).

In order to control variable and reduce errors, the vehicle model was modeled based on Passat. Except above factors, other parameters used default values.

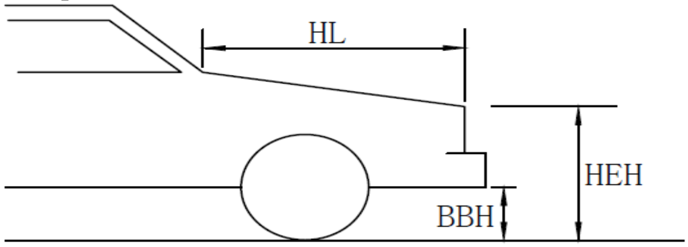

Fig.1 : Front structure

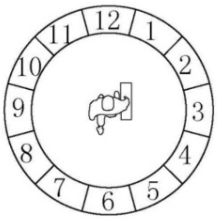

Fig.2 : Impact angle

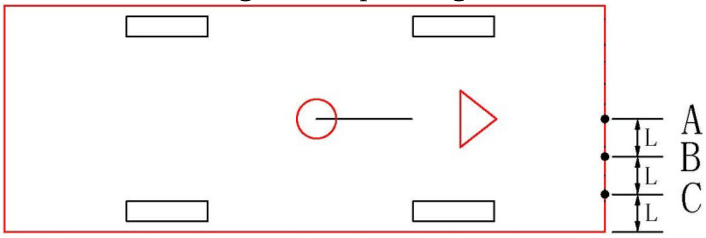

Fig.3 : Impact position, 3L is half of vehicle width.

Human data selected 50th% Chinese adult male, 90th% Chinese adult male and 5th% Chinese adult female. According to common speed limit in the city road, vehicle speeds ranging from 30 to 60 km/h. Pedestrian speeds were based on typical pedestrian walking speed [5]. Accidents often happened at 2-4 and 8-10 o'clock, impact configurations selected 8-10 o'clock because of symmetry, represented 300° , 270° ,240° (see Fig. 2) [6]. Due to the symmetry of the vehicle, the impact position was selected at A, B and C points on the right of vehicle (see Fig. 3). The three types of coefficient selected maximum, minimum and middle value.

Table 1. Parameter value

No.	HEH /m	BBH /m	HL/ m	HH /m	HW /kg	Vv /(km/h)	φ/°	P /m	Vp /(km/h)	fpv	fpg	f
1	0.7	0.2	0.5	1.678	59	30	300	0	0	0.2	0.6	0.7
2	0.8	0.3	0.7	1.754	71	45	270	0.31	2	0.3	0.7	0.8
3	0.9	0.4	1.2	1.484	48	60	240	0.61	5	0.4	0.8	0.9

Orthogonal test

Factor Level and Evaluation Index. Orthogonal experimental was designed, the final distance between last position of car and pedestrian was selected as evaluation index. The parameter values were based on actual statistical data and all parameters have three levels (see Table 1).

Orthogonal Table and Experimental Results. Due to a large number of parameters, the orthogonal table $L_{27}(3^{13})$ was selected. To improve the accuracy of the experiment, the last column was set to empty. Follow the order of orthogonal table, 27 groups test have been done in Pc-crash test, measured and recorded test results (see Table 2).

Range Method. Range method can reflect test index changed with the change of factor value. As the range of factor increases, the influence of factor on the evaluation index increases. According to range of factors, the weights of parameters can be analyzed.

According to the test, vehicle speed, hood length and hood edge height had a great impact on the experimental results. In table 3, the influence of parameters on evaluation index was arranged. In the process of reconstruction, the order of these 12 parameters can be considered as reference. The value of parameter with a large weight should be adjusted in width range and short distance. In contrast, the range of value of parameter with a low weight can be decreased.

Table 2. L_{27}（3^{13}）Orthogonal table

NO.	HEH /m	BBH /m	HL/ m	HH /m	HW /kg	Vv /(km/h)	φ/°	P /m	Vp /(km/h)	f_{pv}	f_{pg}	f	N	D /m
1	0.7	0.2	0.5	1.68	59	30	300	0	0	0.2	0.6	0.7	1	4.7
2	0.7	0.2	0.5	1.68	71	45	270	0.31	2	0.3	0.7	0.8	2	11.21
3	0.7	0.2	0.5	1.68	48	60	240	0.61	5	0.4	0.8	0.9	3	16.23
4	0.7	0.3	0.7	1.75	59	30	300	0.31	2	0.3	0.8	0.9	3	3.17
5	0.7	0.3	0.7	1.75	71	45	270	0.61	5	0.4	0.6	0.7	1	4.99
6	0.7	0.3	0.7	1.75	48	60	240	0	0	0.2	0.7	0.8	2	17.34
7	0.7	0.4	1.2	1.48	59	30	300	0.61	5	0.4	0.7	0.8	2	4.57
8	0.7	0.4	1.2	1.48	71	45	270	0	0	0.2	0.8	0.9	3	10.44
9	0.7	0.4	1.2	1.48	48	60	240	0.31	2	0.3	0.6	0.7	1	18.17
10	0.8	0.2	0.7	1.48	59	45	240	0	2	0.4	0.6	0.8	3	7.05
11	0.8	0.2	0.7	1.48	71	60	300	0.31	5	0.2	0.7	0.9	1	12.92
12	0.8	0.2	0.7	1.48	48	30	270	0.61	0	0.3	0.8	0.7	2	3.76
13	0.8	0.3	1.2	1.68	59	45	240	0.31	5	0.2	0.8	0.7	2	6.12
14	0.8	0.3	1.2	1.68	71	60	300	0.61	0	0.3	0.6	0.8	3	9.27
15	0.8	0.3	1.2	1.68	48	30	270	0	2	0.4	0.7	0.9	1	2.63
16	0.8	0.4	0.5	1.75	59	45	240	0.61	0	0.3	0.7	0.9	1	12.57
17	0.8	0.4	0.5	1.75	71	60	300	0	2	0.4	0.8	0.7	2	18.94
18	0.8	0.4	0.5	1.75	48	30	270	0.31	5	0.2	0.6	0.8	3	3.52
19	0.9	0.2	1.2	1.75	59	60	270	0	5	0.3	0.6	0.9	2	10.21
20	0.9	0.2	1.2	1.75	71	30	240	0.31	0	0.4	0.7	0.7	3	2.78
21	0.9	0.2	1.2	1.75	48	45	300	0.61	2	0.2	0.8	0.8	1	3.39
22	0.9	0.3	0.5	1.48	59	60	270	0.31	0	0.4	0.8	0.8	1	15.17
23	0.9	0.3	0.5	1.48	71	30	240	0.61	2	0.2	0.6	0.9	2	6.32
24	0.9	0.3	0.5	1.48	48	45	300	0	5	0.3	0.7	0.7	3	11.12
25	0.9	0.4	0.7	1.68	59	60	270	0.61	2	0.2	0.7	0.7	3	8.75
26	0.9	0.4	0.7	1.68	71	30	240	0	5	0.3	0.8	0.8	1	4.62
27	0.9	0.4	0.7	1.68	48	45	300	0.31	0	0.4	0.6	0.9	2	7.73

* N represents null columns

Table 3. Range

Factor	Mean1	Mean2	Mean3	Range
Vehicle speed	4.008	8.291	14.111	10.103
Hood length	11.087	7.814	7.509	3.578
Hood edge height	10.091	8.531	7.788	2.303
Impact angle	8.423	7.853	10.133	2.28
Human height	7.918	8.546	9.947	2.029
Impact position	9.672	8.977	7.761	1.911
Bumper bottom height	8.028	8.459	9.923	1.895
Friction coefficient between pedestrian and ground	7.996	9.321	9.093	1.325
Human weight	8.034	9.054	9.321	1.287
Friction coefficient between pedestrian and vehicle	8.167	9.344	8.899	1.177
Pedestrian speed	9.307	8.848	8.256	1.051
Friction coefficient	8.814	8.46	9.136	0.676

In the accident information collection, collectors can pay more attention to the parameters with high weight to improve the accuracy and efficiency of data collection such as hood length and hood edge height. It can not only reduce the workload of data acquisition, also reduce pedestrian-vehicle accident reconstruction error.

In the accident simulation, parameters which can be accurately measured were set at beginning, and then the parameters with low weight according to the recommended value and experience value were set. Finally according to the weight, adjust the parameters with large range. Because some of parameters with a high weight can be accurately measured instead of estimation, such as hood length, the weight of impact position is higher among estimation parameters, it should be careful adjusted.

Compared with real accident

A real case was selected from the NAIS (National Automobile Accident In-Depth Investigation System) to validate the result. In 2013 a day night, rain, wet cement road, a vehicle drove from west to east in Chengdu, and had a collision with a pedestrian crossing the road. The accident resulted in a pedestrian died.

The actual final distance between vehicle and pedestrian is 11.2m (figure 4), the final distance of simulation is 10.6m (figure 5), and the error is about 5%. Generally in the three-dimensional traffic accident reconstruction, when the error is lower than 7%, the reconstruction is acceptable. The method can improve construction efficiency and has been proved to have a high reliability.

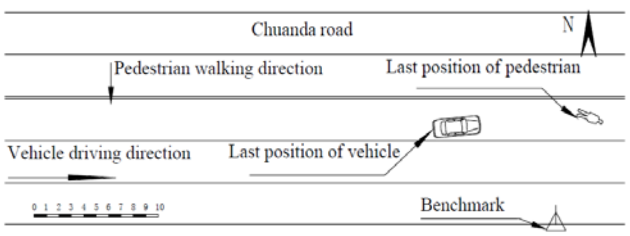

Fig.4 : Accident scene

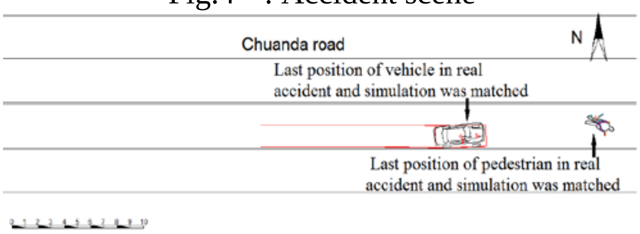

Fig.5 : Simulation

Conclusions

According to the sequence of parameters of weight, adjust the parameter with a high weight. Simulation error can be controlled in the Pc-crash. Thus, the adjusting method in this paper is an effective way to improve construction efficiency and accuracy.

Acknowledgements

This study was supported by the Innovation Fund of Postgraduate, Xihua University, and the NAIS (National Automobile Accident In-Depth Investigation System) of AQSIQ Defective product Administration Center.

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