

Basal Human-vehicle-road Experiments on Traffic Safety and Accident Reconstruction: Layout and Outlook

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Abstract: The basal experiments of research fields on traffic safety and accident reconstruction are discussed, including the relevant investigation for the characteristics of human, vehicle, road and their interaction. The layout of main experiments for accident reconstruction is designed specially, in which the experimental measurement of friction coefficient of road surface have been executed primarily. The experiments related to driver performance and ergonomics are also presented, especially for the applications of driving simulation platform. For the future, these experiments will be performed in succession to improve the research work on traffic safety and accident reconstruction.

Key words: basal experiments, Human-vehicle-road, traffic safety, accident reconstruction, layout

1 Introduction

As a branch study of automotive passive safety, the reconstruction, analysis and statistics of traffic accidents is foundation of the study of traffic safety, which also provides both auto design and automotive safety teaching with basic theory and data. The research on automotive active safety and auto design about vehicle crash safety and human body protection should be based on the statistics and analysis of traffic accidents. In consequence, combined with advanced computer simulation and virtual reality technology, the research of traffic safety and accident reconstruction is carried on not only to meet the need of analysis of the accident process, but also to increase the automobile safety.

Experimental method is an important way in the research of traffic safety. At present, a comprehensive research platform for traffic accident reconstruction is established by the laboratory of Traffic Safety and Accident Reconstruction, which can carry on further research related basal experiments. Taking advantage of the existed basic theory and the study evolution of accident reconstruction, accident statistics, and so on, we could delve in deep into the basal experiment of vehicle braking efficiency, adhesion coefficient, measurement of human parameters, photogrammetry of the accident scene, etc. We can conduct integrated experiments for the parameters that all kinds of typical accident reconstruction need, to provide the study of human-vehicle-road system in traffic safety with related support of data and technology.

2 Contents of experiments

Figure 1 outlines the fundamental contents of the research on Human-vehicle-road system, including experiments on human performance, vehicle performance, road performance and other comprehensive subjects. The basal experiments on traffic accident reconstruction are the main part in the development of the laboratory. In recent years, it has been improved enough to perform the experiments. The experiments related to driving simulation are considered as a development emphasis in the future.

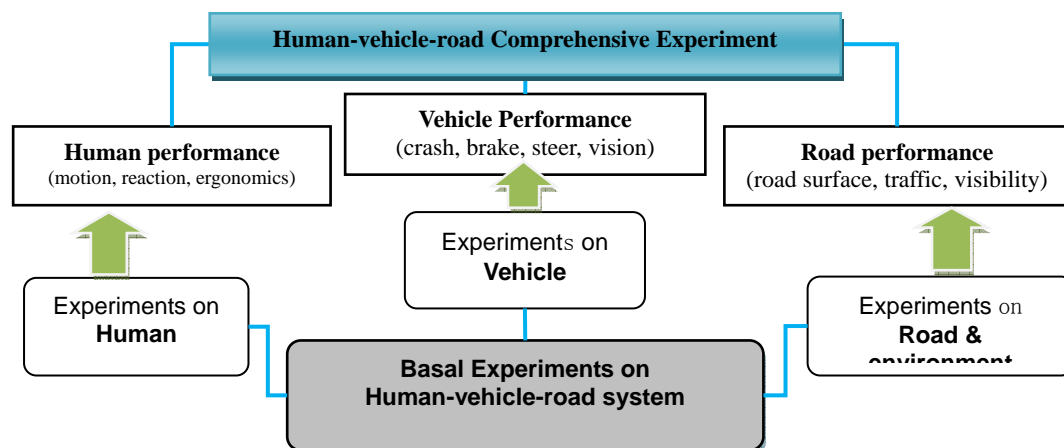


Figure 1 Contents of Traffic Safety and Accident Reconstruction experiment

2.1 Experiments on road

The key parameters in the analysis of traffic accident reconstruction are braking adhesion coefficient and gliding friction coefficient of vehicle on road surface, while there is few experiments in this area. As a result, most of the data in use by now is from experimental results in 1970s to 1980s abroad. However, in the last 20 years, the vehicle performance and road property have been enhanced a lot, so that these parameters have changed a lot. The corresponding data is in great need of updates and additions.

2.2 Experiments of vehicle

By using of the experimental tester to perform a variety of real vehicle-crash experiments in the study of accident reconstruction, the plastic deformation characters of vehicle can be obtained for the needs of research and application. Nowadays, the data of experimental results which were performed in 1970s to 1980s in accident reconstruction analysis is still in use. With the improvement of vehicle collision safety, the vehicle's stiffness has changed to a certain extent. Consequently, it is expected to provide accident reconstruction with new basic data by conducting vehicle-crash experiments upon compact cars, sedans, coaches, vans, and so on respectively.

2.3 Experiments of human

Combined with ergonomics, the experiments on traffic safety mainly concerns the contents related to human factors, such as driver factors in accidents, driving fatigue and driving suitability^[1], driving characteristics, the protection of participants in the traffic system, humanity design of road traffic facility, as well as emergency relief in accidents.

3 Series of experiments on accident reconstruction

The reconstruction and analysis on traffic accident means that researchers, according to the information of the scene and vehicle of the accident, build kinematic and dynamic model after the accident by related theory method and experts' experiences to calculate backward from the starting position of the car, and reconstruct the accident process of space and time to obtain the technical parameters of the vehicle before the crash happened to analysis the cause of the accident. Parameters required by accident reconstruction is shown in table 1, some of which can be obtained only by conducting experiments.

Table 1 Experiment parameters for accident reconstruction

Parameter Type	Parameter list	Experimental methods
Vehicle Parameters	Basic Parameters: vehicle size, weight, rotational inertia, etc.	Measuring real vehicle, reference of vehicle
	Performance parameters: Parameters of vehicle braking and steering.	technical parameters, real vehicle road test
	Characteristics of the collision parameters:	or detection on line, real vehicle crash
	plastic deformation stiffness coefficient, coefficient of resilience, etc.	experiments, statistical data
human parameters	Basic parameters: human height, mass, volume, rotational inertia, etc.	actual measurement, ergonomic experiment
	Motion parameters: speed of the body outside the vehicle , cavorting	
	height, the overturned distance, etc.	
Info of road surface	vehicle stop location, road signs, active site, distribution of scattered objects	actual road surface exploration and testing
environment parameters	Parameters of the road: the road type and characteristics slope, etc.	Real vehicle road test, measurement
	Parameters of the weather: wind speed, quantity of precipitation, as well as the acceleration of gravity and so on.	

3.1 The experiment on braking tire adhesion coefficient

The adhesion coefficient of vehicle braking exerts a considerable influence to the result of accident reconstruction. It is very hard to get the specific value by actual measurement in calculation, thus we have no ideas but to get an estimate value from experts, which will cause a considerable data error. Therefore, it is very important to accumulate data of experiments on road friction coefficient of vehicle braking.

For the identification of traffic accidents, the friction coefficient of vehicle braking is in general use. Currently, the experiments for friction coefficient of typical roads to increase the accuracy of analysis of accident reconstruction is carried out, which will also make a contribution to computer simulation technology of the accident process, accident identification and responsibility verdict. Typical road surface has been selected to test the vertical sliding friction coefficient in different conditions. The contents of recent experiments on performance of vehicle braking are shown as Table 2. In this way, we can find out how the road surface and braking speed affect the quality of adhesion coefficient, by which we can even provide judicial expertise of traffic accident with accurate and first-hand experimental data. The experiment apparatus include deceleration device, laptop, tire pressure gauges, etc.

Table 2 Results of recent experiments on vehicle braking performance

No.	Vehicle type	ABS	Pavement Type	Pavement Condition
1	SUV- A	Yes	Asphalt, cement, dry soil, sand and gravel	Dry
2	SUV- A	Yes	Asphalt	Wet
3	SUV- B	No	Asphalt	Dry
4	CAR-C	Yes	Asphalt, dry soil	Wet

3.2 Experiments of sliding friction coefficient on road surface

In accident reconstruction, the friction coefficient of sliding human body, bicycle and motorcycle sliding on road is often used to estimate the speed of vehicle. Early in the 1980s, there were related experiments carried out abroad^[2], while few people engaged in research on this area in domestic.

(1) The experiments on road surface friction coefficient of human body

The friction coefficient between dressed body and the road surface is important parameter in estimating the crash speed in vehicle collision accident. The experiment on friction coefficient between human body and road surface using the Coulomb law of friction: the value of friction force is in direct proportion to normal force created by touched objects^[3]. The experiment is also performed upon different types of the human body (fat/thin, men/women) wearing different clothes (such as clothes for different seasons). After weighing, different parts of body (For example, fall back, fall down) will be selected to effect with asphalt, concrete, and other typical road surface. After testing the friction force, we can compare the results of the test with the oversea results of experiments and examined by actual cases of accident at the same time.

(2) The experiments on road surface friction coefficient of bicycle

The friction coefficient between bicycles or motorcycle and road surface, when they are sliding on road after their overturning, is one of the parameters that are generally used in the reconstruction and analysis of this kind of accident. After weighting three types of bicycle (24, 26, 28) and two models of motorcycle (such as HK50, AX100, and so on), we select different parts (as the overturning of the left side or right side) to effect with asphalt, concrete, and other typical road surface. This kind of experiment can be performed using the device like the experiments mentioned above.

In recent years, the sliding friction coefficient of human body, bicycle, and motorcycle was tested respectively by the researchers of the laboratory, and the summary of the results is shown in table 3.

Table 3 Experimental results of sliding friction coefficient on road surface

Target under test	Asphalt road	Concrete road	Oversea experimental results ^[2]	Remark
26-bicycle	0.44~0.48	0.49~0.5	0.51~0.56	Dry road surface in winter
28-bicycle	0.49~0.57			Snow and ice road surface: 0.41~0.45
Two-wheeled motorcycle	0.59~0.61	>0.55	0.55~0.7	Model:HK50、AX100
Dressed body	0.49~0.51		0.4~0.6	Adult men, winter clothes,74kg

3.3 The ergonomics-related experiments

In the area of traffic safety, experiments related to ergonomics include measurement of human parameters, measurement of driver's visual field, humanity design of road traffic facility, human factors in traffic accidents, human fatigue, driving characteristics, as well as the protection of participants in the traffic. These experimental contents refers to ergonomics, human physiology, biomechanics, psychology and other disciplines related, are playing an important part to increase traffic safety and promote body comfortableness. Sometimes, it is impossible to carry out the specific experimental measurement, based on principles of ergonomics, the weight, height or some other basic parameters of human body has to be set by the human body parameters in different percentile by ergonomics theory.

Accident Reconstruction requires for the parameters of human motion, including the speed of walking, running and cycling. As a result of the differences between people's exercise performance, the purpose of travel, the environment, traffic density and so on, the parameters of each person's motion is different, so experimental data in this area should be accumulated to provide reference for the research fields on traffic safety and accident reconstruction.

4 Experiments based on driving simulator

Our driving simulator of integrated experimental platform was completed in April, 2009, which has achieved domestic advanced level. It provides important fundamental platform in the field of automotive intelligent security, advanced vehicle design, traffic safety and accident reconstruction, driver behavior sciences, etc.

The technology used in this integrated platform, operated by a real driver in a real car under a virtual environment, includes computer technology, automatic control, 3D imaging technique, auditory simulation, virtual reality and other related advanced technologies. So that the driver can drive the car just as usual, like on the ordinary road, by simulating the driver's vision, hearing, control and movement feeling. In this way, some very dangerous experiments on the real road can be carried out on the experimental platform under conditions of risk-free, such as experiments of fatigue driving, drive in drunk and other non-normal driving behavior, even some collision experiments. As following, the current pilot projects will be carried out.

4.1 Typical traffic accidents simulation and causation analysis.

We can simulate typical traffic accident scenario via the driving simulation platform, such as rear-end accident on freeway, side-impact of urban road intersection, pedestrian-impact, etc. During the simulation of traffic accident, a real driver will drive the simulator to get pre-accident parameters by methods of typical traffic accident reconstruction. These parameters include vehicle speed, contact characteristics, driver behavior, and some other parameters of People-Vehicle-Road factor and characteristics. Several parameters related to accidents will be set or simulated to examine the rationality of the result of the traffic accident reconstruction, as

well as to obtain driver's characteristics of critical reaction to further explore the causation of the accident and the possibility of avoiding the accident, like braking and steering operations of driver.

4.2 Drunk and other non-normal driving simulation

Based on the theory of ergonomics, forensics, physiology and so on, the experiments related to drunk and other non-normal driving simulation are carried out via the driving simulator. During this kind of experiments, researchers should design practical experimental program to study on the relationship among the blood alcohol content and the driver's reaction time, operating precision, driving safety, etc. Combined with investigation and in-depth analysis on actual accidents, the research on this field can provide necessary reference for the relevance between drunk driving and accident-causing, active safety protection and improvement of relevant laws and regulations respectively.

4.3 Human-Machine-Environment System evaluation and analysis of the driving simulator

The HMES evaluation and analysis of the driving simulator is carried out based on the theory of ergonomics. By establishing the objective and subjective evaluation system of the HMES ergonomic performance, combined with driving simulated experiments in the actual traffic scenarios, we can analyze and evaluate the control convenience, comfort, visibility, credibility of the driving simulator and some other performances to improve the settings of the man-machine interface of the driving simulation platform and environment simulation.

4.4 Measurement and simulation of the effect of road environment visibility

The study of visibility measurement of the actual road environment is to obtain the features of the visibility in different season, time or climate, contributing to data collection of traffic scene, and provides the setting of the visibility of the driving simulator with references. By measuring the visibility of the actual accident scene, photograph or video to make the quantitative description of some characteristics in light environment like visibility, we can provide the simulation of accident with parameters in light environment that are close to the reality, which will make the effect of the simulation more reliable.

5 Conclusions

In this paper, the design and layout of basal Human-vehicle-road experimental contents and methods on traffic safety and accident reconstruction are explored, which can be summarized as the experiments on accident reconstruction, vehicle safety performance, traffic safety, ergonomic and other related experiments. The summary on road surface friction coefficient experiments and the layout of driving simulation are presented respectively. Combined with the existed foundation of the work and our further research plan, we will focus our experiments on the accident reconstruction and its improvement in the future. We will make a deeper development on the experimental apparatus, and carry out more related experiments to meet the needs of both teaching and investigation, to advance the development of research on traffic accident reconstruction.

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