Application research on identification of bicycle-vehicle traffic accident using computer simulation technology

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Abstract. The determination of driving state of non-motorized vehicle before traffic accident has very important significance for the identification of non-motorized vehicle and vehicle traffic accident. Based on a typical case of traffic accident of vehicle and non-motor vehicle, the injury degree is consistent with actual conditions in simulated driving state by simulation reappearance of Pc-Crash and analysis for injury results of human biomechanics and actual conditions. Combined with traces of vehicle and bicycle, the moving state of bicycle can be identified as the driving state before traffic accident occur comprehensively. Thus, it is of great significance to identify the responsibility party in the identification items of traffic accident of non-motor vehicles and improve the justice and reliability of judicial expertise in traffic accidents.

Introduction

For a long time, mixed running of motor vehicle and non-motor vehicle have been a major feature of urban traffics in many cities of China[1]. Meanwhile, collision accidents of cars and bicycles have been one of the main forms of urban traffic accidents in our country. The bicycle had become a major public transportation in the city because of its adaptability of public needs, flexibility and convenience, the economical and practical, etc, which caused a large amounts of collision accidents of non-motor vehicle and motor vehicle. Currently, although a variety of researches on non-motor vehicle accidents, there are few researches about driving state of non-motor vehicle before determine one accident. Based on a real traffic accident case, this paper is to compare vehicle trace with human's dynamic response parameters and accidental investigation records by means of Pc-Crash and then determine the driving state of non-motor vehicle before accidents appearance.

Impact biomechanics and injury criterion

Abbreviated injury scale

The Abbreviated Injury Scale (AIS) is a criterion based on an anatomic scale divided in six different levels that define the kind of injury and respective severity level for each part of the human body and the higher the AIS value, the higher the respective injury severity, culminating in death. There is a direct correlation between HIC and AIS that enables the conversion of the head acceleration levels determined in computational simulations into injury severity [2,3].

Human body dynamic injury

HIC (head injury criterion) is generally used as the criterion of human bead. And usually use

HIC=1000 as a safety margin in domestic and foreign standard. The formula (1)[4] is:

$$HIC = MAX\left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} R(t)\,dt\right]^{2.5}(t_2 - t_1) \tag{1}$$

In Eq. 1:t_1 and t_2 are chosen in order to maximize the HIC value, and a (m/s^2) is the resultant linear acceleration measured at the center of mass of head.

In addition to head injury, collision process is often accompanied with human torso injury, caused by knock to the vehicle or ground. And usually use torso resultant acceleration (60g) within 3ms as a safe threshold value. In addition to the above-mentioned, human injury also includes TTI (thoracic injuries index), VC (viscous damage), and ASA (average thoracic spine acceleration).Lower extremity injury includes: ligament sprain, fracture, tendon injuries, and muscle tear. The extent of its injury is influenced by the force and torque in the collision time.

Accident introduction

One morning, the weather is fine and the road is in good condition. A car steered along a tarmac from east to west and it collided with a bicycle driving from south to north. As a result, both were damaged in different degrees. Among it, the cyclist was injured badly.

The bicycle owner is a female. The diagnoses in hospital show that both eyes had blunt trauma and there are ecchymosis under the left eyelid. The right fibula is diagnosed as a comminuted fracture and the right internal anklebone is fractured.The left breast feels pain when it is pressed and there is no tenderness and rebound tenderness.According to the accident,the simulation model of vehicle-bicycle and rider can be built by Pc-Crash software.

Analysis

Accident reconstruction result analysis

There are four figures which are human injury results calculated by Pc-Crash. They are respectively torso acceleration curve, head acceleration curve, right foot rotation angle response curve and right lower leg shear stress curve from Fig.1 to Fig.4.

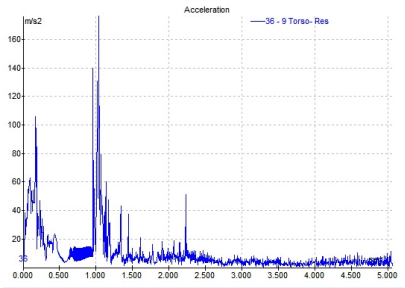


Fig. 1 torso acceleration curve

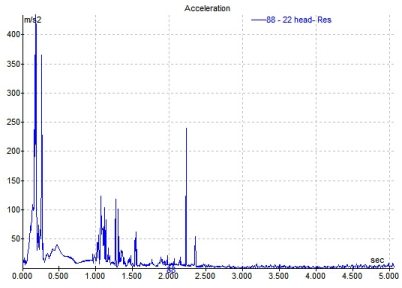


Fig. 2 head acceleration curve

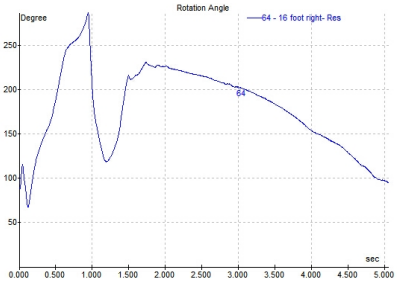


Fig. 3 right foot rotation angle response curve

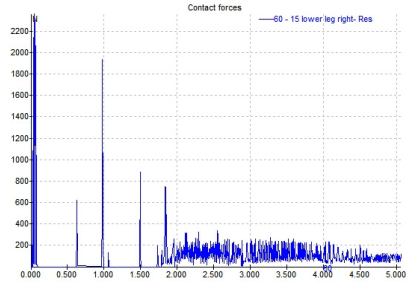


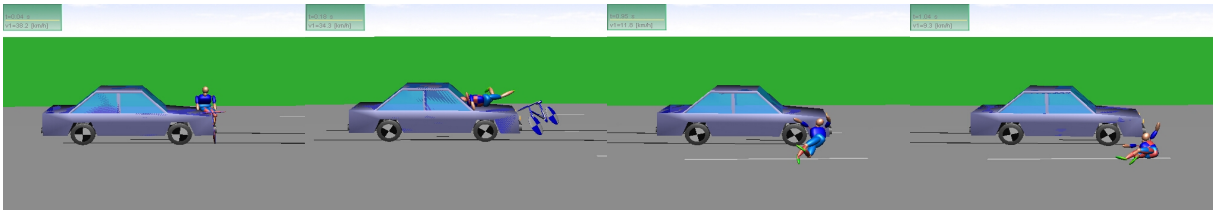
Fig. 4 right lower leg shear stress curve

As is shown in Fig.1, the maximum value of acceleration speed can reach the peak 187.34m/s^2 (19.12g) in 1.040s because of her body's contact with ground habitually. According to the simulation results, the maximum value by computed are less than the safe threshold value of torso's resultant acceleration (60g) within 3ms. Based on the cases prove issued by hospital, it can be inferred that the non-great-injury to cyclist's body is consistent with the simulation results such as the left breast's tenderness, soft and plain abdomen, aches without pressure and rebound tenderness, etc.

The Fig.2 shows that the collision between head and front windshield will occur and the acceleration will reach the maximum 428.06 m/s^2 in 0.180s.If we put peak acceleration 428.06 m/s2 into formula(1), we can get the HIC =189.14, which is less than the safety margin number of 1,000. It is consistent with the cases prove issued by hospital, which shows the contusion in cyclist's eyes, congestion in right eyelid of her head and non-great- injury to her head.

As is shown in Fig.3, the right foot hit to the ground in 0.950s and then it make her right foot rotate, the maximum is 286.47°. Such a large rotation exceeded its sport load and caused the injury, which is consistent with the diagnosis result of a comminuted fracture on the rider's right fibula by internal medicine in hospital.

As is shown in Fig.4, cyclist's right calf firstly contacted the front bumper in 0.045s and its corresponding shear stress came to the first peak, namely the maximum 2352.05N.Such a strong shear stress can cause fractures on right calf that is consistent with medical record of internal medicine in hospital, which is diagnosed as a comminuted fracture on the rider's right fibula.



(a)T=0.045s (b)T=0.180s (c)T=0.950s (d)T=1.040s

Fig. 5 relative position of vehicle-non motor vehicle-cyclist

The relative position of vehicle-non motor vehicle-cyclist is shown in Fig. 5. As is shown in Fig.5(a),the cyclist's right calf contacts with the front bumper in 0.045s;the cyclist's head contacts with the front windshield in 0.180s,such impact makes the acceleration reach the maximum,however, the created impact force is not enough to make a severe injury;In 0.950s, the human body contacts with the ground after impact and the created force makes the right foot rotate. The created rotation degree reaches the peak which is shown in Fig. 3;In 1.040s, the torso hits to the ground which is shown in Fig. 5(d), and the created force makes the acceleration of torso reach the peak which is shown in Fig. 1.

Trace analysis

After inspecting the car and bicycle, the specific information of their tracks should be recorded and compared by means of observational methods. Finally, it come to the conclusion as bellows:

Firstly, according to left rotation analysis for bicycle seat, it can be found that its formation is basically consistent with the supposition that the bicycle's deformation is triggered under huge gravity. Based on the analysis for fracture trauma of right inner anklebone of bicycle's owner, the injured part is low and it can't be caused under the condition of pushing bicycle.

Secondly, the car's scratch is left on the left front side of the car, which is triggered by scratch and collision force from front to back. However, the bicycle's scratch is left on the right back side

of itself, which is caused by scratch and collision force from right to left.

Thirdly, by comparison with vehicle's vestigial condition, height, features and deformation conditions, it can be found that those are the main points of impact which include the vehicle's front bumper, left headlight, engine hood, right holder of bicycle's backseat, right spindle head of back wheel and right side of back basket. Besides, the vehicle's vestigial condition, features and attachment's color are consistent with that of bicycle. Moreover, the engine hood and front windshield of vehicle is caused by contact with non-hard objects, which is consistent with the fact of collision of vehicle and bicycle in collision accident.

Summary

The driving state of non-motor vehicle played a crucial role in the responsibility identification for traffic accident when motor vehicle and non-motor vehicle crashed on the road. It came to the conclusion as bellows based on the analysis for simulation reappearance of a typical non-motor vehicle traffic accident.

1.It can be found that bicycle tracks generated in the moving state and the bicycle's owner is in the driving state when the collision accidents occurred by the comparative analysis for tracks.

2.It can also be found that the injury degree of bicycles' owners in simulated state is consistent with real fact basically and the motion state of bicycles' owner is also consistent with simulation state in traffic accident appearance through serious analysis for injury results of human body and real facts.

3.Based on the above two points, the determination for driving state of non-motor vehicle in collision accidents can be applied to other similar traffic accidents. Moreover, the affirmative way is vivid and straightforward, accurate and rational so that it has a certain reference value for identifying the similar collision accidents.

On account of author's low ability in researching and uncertain effects of various parameters, the reconstruction process of accident remains to be further explored, which include the selection of optimal parameters and control for parameter uncertainty, etc.

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