NEAR-CRASH SCENARIO IN CHINA BASED ON SHANGHAI DRIVING DATA

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ABSTRACT

In 1995, there were 1.4 million automobiles in China. In 2010, the number of automobiles reached 18.27 million, including 9.576 million passenger vehicles [1]. With such rapidly growing capacity, traffic safety is becoming increasingly important. In 2010, there were 3,906,173 accidents, 65,225 fatalities, and 254,075 injuries reported by the Chinese official statistics [2].

Crash scenario typologies have been widely used in support of identifying crash intervention opportunities, setting research priorities and direction in safety technology development, and evaluating the effectiveness of selected crash countermeasure systems. The objective of this study is to collect data and to develop a list of representative near-crash scenarios. The developed frequency distribution of typical near-crash scenario can help identifying intervention technology development opportunities for collision avoidance.

INTRODUCTION

Real-world accidents and near-crash cases provide the necessary data to develop control algorithms to avoid accidents, as well as to prepare vehicles for inevitable crashes. Crashes typology in the U.S. has been developed by General Motors (GM) and adopted by automakers for the design, development, and benefits assessment of potential crash countermeasure technologies [3]. Near-crash scenario typologies have been gaining strong research interests in recent years. A near-crash is referred to a successful crash avoidance event, where a successful, last-second evasive maneuver is required to avoid a crash. Near-crash studies can provide unique insight into the elements and factors associated with successful crash avoidance maneuvers for comparison to unsuccessful or crash circumstances. The 100-Car Naturalistic Driving Study completed by the Virginia Tech Transportation Institute, is the first instrumented-vehicle study undertaken with the primary purpose of collecting near-crash, pre-crash, crash, and naturalistic driving data [4].

This study instrumented ten taxis with drive recorder (Horiba TWINs) to collect naturalistic driving data. The data collected between February 2011 and July 2012 were combined with data collected from four taxis with Video Drive Recorder (Horiba VDR) between September 2008 and September 2009. The top six near-crash scenarios are presented in this paper.

METHODOLOGY

Two sets of data were used in the analysis. Both sets of data were from taxis travelled in Jiading District in Shanghai under normal driving conditions. No special instructions were given to the drivers. The first set of data was collected from four taxis with Video Drive Recorder (VDR) between September 2008 and September 2009 (Figure 1). Each VDR had one camera focusing on the road in front. The forward image, vehicle traveling velocity, and vehicle accelerations in the longitudinal, lateral, and vertical directions were monitored continuously and recorded for a 20 second period, 15 seconds prior to the trigger and 5 seconds after the trigger. The second set of data was collected from ten taxis with drive recorder TWINs between February 2011 and July 2012. Each TWIN had two cameras, one focusing on the road in front, and the other focusing on the driver (Figure 2). The additional data from TWINs included the vehicle interior image focusing on the driver and the GPS data. The trigger for data collection was set at 0.4 g in any direction. This conservative approach is to avoid missing any near-crash cases. After carefully viewing the logged data video images, vehicle velocity, and the specific driving environment, cases without any inherent collision potential were excluded from the near-crash cases. The events requiring a rapid, evasive maneuver to avoid a crash were considered as a near-crash case.

To identify all common pre-crash scenarios of all police-reported crashes involving at least one light vehicle, NHTSA defined and statistically described a pre-crash scenario typology for light vehicles based on the 2004 General Estimates System (GES) crash database [2]. Single-vehicle and two-vehicle crashes of common crash types were analyzed and produced the list of 37 representative pre-crash scenarios [2]. These 37 pre-crash scenario definitions developed by NHTSA were used to characterize near-crash cases collected in the current study. The top most frequent scenarios were compared.

Figure 1. Horiba VDR instrumentation. Data included forward image, vehicle traveling velocity, and vehicle accelerations in the longitudinal, lateral, and vertical directions.

Figure 2. Horiba TWIN instrumentation. Data included forward image, interior image focusing on the driver, vehicle traveling velocity, vehicle accelerations in the longitudinal, lateral, and vertical directions, and GPS data.

RESULTS

There were a total of 1,420 cases collected from VDR instrumented taxies and TWIN instrumented taxies. Of them, 11 cases were actual crashes. After carefully reviewing each of those non-crash cases, 430 cases were judged as near-crash cases and were further analyzed. Table 1 shows the comparison of six most frequent scenarios. In NHTSA's analysis, the six most frequent scenarios accounted for 51% of all police-reported light-vehicle crashes. In current Shanghai analysis, the six most frequent scenarios accounted for 70% of all near crashes. The most frequent scenarios from both studies include "Lead Vehicle Decelerating" and "Vehicle(s) Changing Lanes - Traveling in Same Direction". Two types of single vehicle crashes were in NHTSA's top six of the most frequent scenarios ("Control Loss Without Prior Vehicle Action" and "Road Edge Departure Without Prior Vehicle Maneuver"). Three out of six most frequent Shanghai scenarios included vulnerable road users ("Two Wheeler Crash – Vehicle Going Straight", "Two Wheeler Crash – Vehicle Turning", "Pedestrian Crash - Vehicle Going Straight").

The top six most frequent Shanghai near-crash scenarios involve either two vehicles or one vehicle with a vulnerable road user. There was no single vehicle near crash in the analyzed 430 cases. A typical "Lead Vehicle Decelerating" scenario can be described as: vehicle is going straight and following another lead vehicle on a surface road, in daylight, under clear weather conditions, at a non-junction with a posted speed limit ranging from 30 km/h to 60 km/h; and the lead vehicle suddenly decelerates. A typical "Two Wheeler Crash - Vehicle Going Straight" scenario can be described as: vehicle is going straight on a surface road, in daylight, under clear weather conditions, with a posted speed limit ranging from 30 km/h to 60 km/h and encounters a two wheeler at a non-junction location. Two wheelers include motor bikes, electric bikes, and bicycles. A typical "Two Wheeler Crash – Vehicle Turning" scenario can be described as: vehicle is turning right or left on a surface road, in daylight, under clear weather conditions, with a posted speed limit ranging from 30 km/h to 60 km/h; and encounters a two wheeler at an intersection. A typical "Vehicle(s) Changing Lanes - Traveling in Same Direction" scenario can be described as: vehicle is changing lane on a surface road, in daylight, under clear weather conditions, with a posted speed limit ranging from 30 km/h to 60 km/h; and encroaches into another vehicle traveling in the same direction. A typical "Vehicle(s) Drifting - Traveling in Same Direction" scenario can be described as: vehicle is going straight on a surface road, in daylight, under clear weather conditions, at a non-junction with a posted speed with a posted speed limit ranging from 30 km/h to 60 km/h; and then drifts into an adjacent vehicle traveling in the same direction. A typical "Pedestrian Crash - Vehicle Going Straight" scenario can be described as: vehicle is going straight on a surface road, in daylight, under clear weather conditions, with a posted speed limit ranging from 30 km/h to 60 km/h; and encounters a pedestrian at a non-junction location. Figure 3 depicts the top six common scenarios.

Table 1. Top six pre-crash scenarios comparison between NHTSA's study and current study

Top 6 pre-crash scenarios based on US 2004 GES crash database [2]		Top 6 pre-crash scenarios based on 430 near-crash cases in Jiading, Shanghai	
Scenario	**Frequency**	**Scenario**	**Frequency**
Lead Vehicle Stopped	16.41%	Lead Vehicle Decelerating	20.50%
Control Loss Without Prior Vehicle Action	8.90%	Two Wheeler Crash - Vehicle Going Straight	20.08%
Vehicle(s) Turning at Non-Signalized Junctions	7.32%	Two Wheeler Crash - Vehicle Turning	13.46%
Lead Vehicle Decelerating	7.20%	Vehicle(s) Changing Lanes - Traveling in Same Direction	7.25%
Vehicle(s) Changing Lanes - Traveling in Same Direction	5.69%	Vehicle(s) Drifting - Traveling in Same Direction	4.76%
Road Edge Departure Without Prior Vehicle Maneuver	5.62%	Pedestrian Crash - Vehicle Going Straight	4.35%

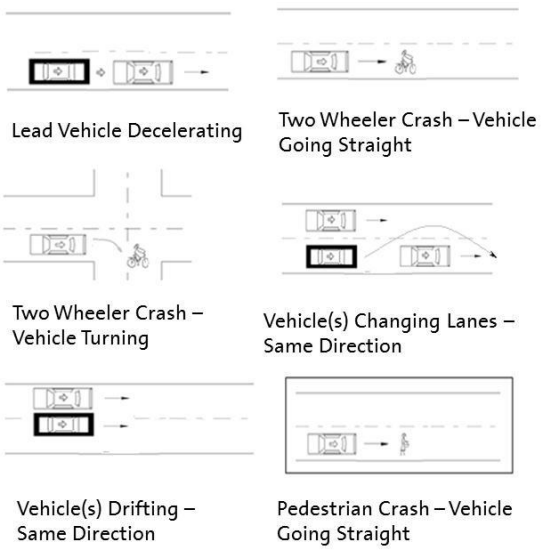

Figure 3. The top six common scenarios from current study.

The recorded velocities were studied as vehicle kinematics for the top six common scenarios. The data frequency is only 30 Hz for current instrumentation. Figure 5 shows the velocity vs. time for a number of vehicles that experienced the "Two Wheeler Crash - Vehicle Going Straight" scenario.

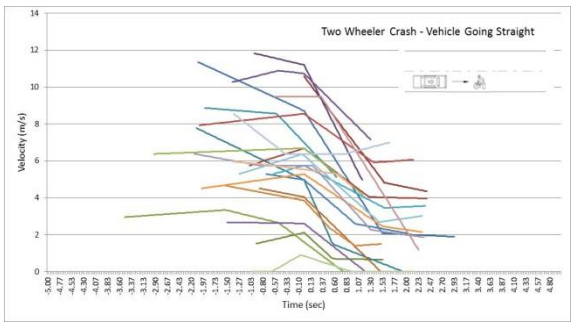

Figure 4. Vehicle velocity for a number of vehicles experienced the "Two Wheeler Crash Without Prior Vehicle Maneuver" scenario.

A critical braking phase was observed from every one of these cases. Following such critical braking (defined as highest deceleration), the studied vehicle successfully avoided the potential collisions (Figure 5).

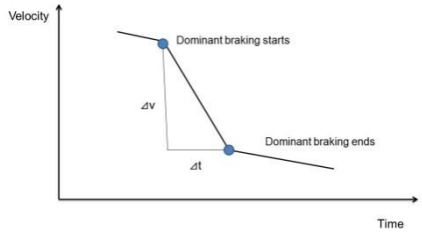

Figure 5. A representative critical braking phase in near crashes

The time duration and the velocity change were analyzed during the critical braking phase for all six scenarios. Table 2 shows the average time duration and the average velocity change during the critical braking for the top six most frequent scenarios.

Table 2. The average time duration and the average velocity change during the critical braking

Scenario	⊿t (sec)	⊿v (m/s)
Lead Vehicle Decelerating	1.53	4.43
Two Wheeler Crash - Vehicle Going Straight	1.28	3.76
Two Wheeler Crash - Vehicle Turning	0.86	2.40
Vehicle(s) Changing Lanes - Traveling in Same Direction	1.20	3.82
Vehicle(s) Drifting - Traveling in Same Direction	1.33	3.22
Pedestrian Crash - Vehicle Going Straight	1.58	3.68

For the near-crash scenarios in the same motor lane, including "Lead Vehicle Decelerating", "Two Wheeler Crash - Vehicle Going Straight", and "Pedestrian Crash - Vehicle Going Straight"), the conflicts with two wheelers showed the shortest braking time, and the conflict with a vehicle showed the highest velocity change. For the near-crash scenarios involving two wheelers, the conflicts at intersections ("Two Wheeler Crash – Vehicle Turning") showed shorter braking time and lower velocity change. The near-crash scenarios involving lane change ("Vehicle Changing Lane" and "Vehicle Drafting") showed similar braking characteristics.

Data from ten taxis with drive recorder TWINs had the vehicle interior image focusing on the driver. The driver images were analyzed together with the forward road images to study driver and environment risky factors which may lead to near-

crashes. Of the 100 cases we analyzed, forty-six cases were due to unexpected opponent movements, such as leading vehicle decelerating, unexpected two wheelers getting into path, etc. Twenty-three cases involved aggressive movements of both objects, such as lane hovering. Twenty-one cases were caused by the subject vehicle itself, such as changing lanes, driver inattention. Ten cases had blocked opponent, such as pedestrians coming out of a light pole.

The results from the current study were compared to a previous study in Beijing [5]. The Beijing study concluded that rear-end conflicts were the most common type (41%). The current study revealed similar trend (Table 1, 20.5% "Lead Vehicle Decelerating"). The current study also revealed that two wheeler conflicts while a vehicle is going straight or turning, are very common (33.46%, Table 1). However, since both studies only used data from a small sample of taxis in a mega city like Beijing or Shanghai, the results may not be generalized to represent the characteristic of all near-crashes in China.

CONCLUSIONS

Four hundred thirty near crash cases were analyzed from a two and a half years' data collection of instrumented taxis in Jiading district of Shanghai. The previously developed 37 pre-crash scenarios definitions by NHTSA were used to study near-crash cases collected in the current study. The six most frequent scenarios accounted for 70% of all near crashes. Three out of six of the most frequent Shanghai scenarios included vulnerable road users. There was no single vehicle near-crash in the studied 430 near crash cases. The most frequent Shanghai near-crash scenarios involve either two vehicles or one vehicle with a vulnerable road user.

All vehicles exhibited a critical braking phase and successfully avoided the potential collisions. The braking characteristics were studied for each scenario and quantified using braking time duration and the velocity change.

Using the vehicle interior images together with the forward road images, we found that an unexpected opponent movement is the leading cause of near-crashes.

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