Quantitative analysis of rear-end crashes and near crashes in a commercial fleet in Shanghai

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Background

Previous research conducted in Western countries concluded that rear-end conflicts occur due to a combination of off-path glances (e.g. towards in-vehicle devices or mirrors) and the simultaneous rapid change in the situation kinematics, manifested by an increase of visual looming. More detailed quantitative analyses – conducted to better understand the factors behind rear-end crashes and to develop countermeasures – reported the following results:

The mean duration of last off-path glances before driver’s reaction (e.g. braking) was 1.84 seconds for crashes and 1.51 seconds for near crashes.

The mean time headway to the lead vehicle at the start of the last off-path glance was 2.62 seconds for crashes 2.54 seconds for near crashes.

The mean value of inverse time to collision or looming increased from 0.17 seconds to 0.52 seconds for crashes and from 0.07 seconds to 0.19 seconds for near crashes, in the time elapsed between the start and the end of the last off-path glance.

Aim

Similar quantitative analyses have not been conducted yet for rear-end conflicts in China. To fill this research gap, this paper aims to: 1) assess drivers’ off-path glances and kinematic relevant parameters (e.g. looming) in rear-end conflicts occurring in a commercial fleet in Shanghai; 2) compare the results to previous studies conducted in Western countries. Those analyses will provide interesting results for the development of active safety systems and autonomous driving in China.

Method

The dataset analyzed in this paper includes 51 rear-end near crashes and crashes (CNC) collected during a 12-months naturalistic driving study, involving 47 commercial vehicles in Shanghai. All vehicles were equipped with a Video Event Recorder (VER) which integrated a variety of sensors and stored safety critical events every time a strong longitudinal or lateral acceleration was triggered. The safety critical events had a duration of 12 seconds – 8 seconds before and 4 seconds after the trigger – and the collected information included videos of forward and driver view cameras (4 Hz sample frequency), longitudinal, lateral and vertical accelerations (20 Hz sample frequency) and speed (1 Hz sample frequency).

The videos of the front and driver view cameras from the 51 rear-end events were coded to extract the following variables:

On-path and off-path glances

Kinematic parameters such as the optical angle $\theta$, optical expansion rate $\dot{\theta}$, the inverse time to collision and the time headway (THW)
Results

The results reported in this section consider together crashes and near crashes – referred as CNC – given the small number of crashes available in the dataset.

The cumulative distribution of time spent by drivers to look at different locations shows that on-path glances occurred for almost 80% of the time in the overall dataset. However, looking at each event individually, the results illustrate that drivers’ off-path glances were present in 70.8% of CNC and, for those events, the mean duration of the last off-path glance was 1.16 seconds.

With respect to the time headway, the results show that its mean value was 1.29 seconds at the start of the last off-path glance. So, most drivers (87.5%) started to glance off-path despite the THW was short, defined as smaller than 1.75 seconds.

Finally, smaller values of mean inverse time to collision were found at the start of last off-road glance (0.03 seconds) compared to its end (0.10 seconds). This result indicates that, in average, the criticality of the situation increased while the drivers were looking away.

Conclusions

The analyses show that, among Chinese drivers, off-road glances are rare and when they occur, their mean duration (1.16 seconds) is lower compared to previous values found for near crashes in Western countries (1.51 seconds). Besides, those off-path glances start at an average value of time headway (1.29 seconds) which is much shorter than the corresponding one found for near crashes in Western countries (2.54 seconds). Finally, the mean value of inverse time to collision in the present dataset assumed smaller values both at the start (0.03 vs. 0.07) and at the end (0.10 vs. 0.19) of the last off-path glance compared to the results reported for near crashes in Western countries.