An Approach for the Estimation of Error Rates in Observing Critical Situations

Andreas Leich[a], Hagen Saul[a], Andreas Luber[a], Ragna Hoffmann[a]

[a]Institute of Transportation Systems, Rutherfordstr. 2, 12489 Berlin, Germany;

ABSTRACT

In this paper the observation quality of critical situations in road traffic is analyzed. Determining the frequency of critical situations is a well-established approach in road traffic safety studies. Situations where a time to collision (TTC) of two road users, a post encroachment time (PET), a deceleration rate needed to avoid a crash (DRAC) or other so called surrogate safety measures exhibit parameter values below or above critical levels are considered as critical. Locations on the road where such situations occur more frequent than average can be regarded as dangerous locations. Countermeasures (e.g. speed limits) can be recommended by traffic safety work practitioners in this case.

The approach of conflict studies has gained popularity in the recent years; because such studies can be conducted more efficiency using emerging automated image processing techniques. Calculating a TTC, DRAC or PET requires recording the trajectories and estimating the object boundaries of road users involved in a conflict.

However, the detection, tracking and boundary estimation operations needed for surrogate safety measure parameter values are subject to measurement errors. Measurement errors cause misdetections. Misdetections can lead to an over- and underestimation of the true rate of occurrence of critical situations. The goal of this paper is to shed light on the detection accuracy of a video based system for the automated detection of a critical situation in road traffic.

First, a mathematical model for the calculation of error rates is introduced. For simplicity, the model is deduced for so called rear end TTC conflicts. If one road user follows another and the velocity of the leader drops, the TTC indicates how much time is left until the follower crashes into the rear end of the leader given both fail to react and maintain their speed. A TTC below some threshold (e.g. $0,5s$ or $1,5s$) is considered as critical. The error rate is therefore influenced by (i) the measurement errors of velocity, location and boundary estimation and (ii) by the statistical distributions of velocity differences and headways of the road users. While the calculation of the first is straightforward, calculating the latter requires Bayesian approach and a-priori knowledge of the joint probability density distribution of the speed differences and headways.

In this paper, a corresponding calculation scheme is deduced and applied to the problem of error rate calculation. In this context, the joint probability distribution is estimated by the joint frequency distribution of velocity difference and headway from a publicly available data set of the Intelligent Cruise Control Field Operational Test study.

The mathematically predicted error rates are evaluated versus detection data of a state of the art video surveillance system applied to a real world test site. Data from 14 different days in different lighting and weather conditions was used. The false positive detection rate is determined manually by reviewing critical TTC situations automatically detected by the surveillance system. Minor deviations and larger discrepancies between predicted and recorded error rates are being discussed in the conclusions of the paper.

Further author information: (Send correspondence to A.L.)
A.L.: E-mail: andreas.leich@dlr.de, Telephone: +49 30 67055409
M.J.: E-mail: marek.junghans@dlr.de, Telephone: +49 30 67055214