CHALMERS

Predicting Safety Benefits of Automated Emergency Braking at Intersections

Virtual simulations based on real-world accident data

ULRICH SANDER

Thesis submitted for the degree of Doctor of Philosophy
in Machine and Vehicle Systems
at the Department of Mechanics and Maritime Sciences,
Chalmers University of Technology, Gothenburg, Sweden.

To be defended in public, 10.15 a.m., Monday October 15th, 2018
in KC Kemigården 4, Gothenburg.

Faculty opponent
Professor H. Clay Gabler, Ph.D.
Department of Biomedical Engineering and Mechanics
Virginia Tech University, USA

Department of Mechanics and Maritime Sciences
CHALMERS UNIVERSITY OF TECHNOLOGY
SE-412 96 Gothenburg
Telephone +46 (0)31-772 1000

Predicting Safety Benefits of Automated Emergency Braking at Intersections
Virtual simulations based on real-world accident data

ULRICH SANDER
Department of Mechanics and Maritime Sciences
Chalmers University of Technology

ABSTRACT

Introduction: Intersections are a global traffic safety concern. In the United States, around half of all fatal road traffic accidents take place at intersections or were related to them. In the European Union, about one fifth of road traffic fatalities occur at intersections.

Intersection Automated Emergency Braking (AEB) seems to be a promising technology with which to address intersection accidents, as information retrieval by on-board sensing is operational on its own, and, in critical situations, braking is initiated independent of driver reaction. The objective of this thesis is to evaluate the effectiveness of a theoretical Intersection AEB system in avoiding accidents and mitigating injuries. As it will take several decades for a new safety technology to penetrate the vehicle fleet and full coverage of all vehicles may never be achieved, the technology benefit is here analyzed as a function of market penetration. Finally, this research assesses whether a set of test scenarios can be derived without compromising the variance of real-world accidents.

Methods: To investigate Intersection AEB in detail, the German In-Depth Accident Study (GIDAS) data and the related Pre-Crash Matrix (PCM) were utilized to re-simulate accidents with and without Intersection AEB using different parameter settings of technical aspects and driver comfort boundaries. Machine learning techniques were used to identify opportunities for data clustering.

Result: On-board sensing has a substantially higher capability to save lives than V2X communication during the period before full market penetration of both is reached. The analysis of GIDAS and PCM data indicate that about two thirds of left-turn across path accidents with oncoming traffic (LTAP/OD) and about 80 percent of straight crossing path (SCP) accidents can be avoid by an idealized Intersection AEB. Moderate to fatal injuries could be avoided to an even higher extent. Key parameters impacting effectiveness are vehicle speed and potential path choice; to increase effectiveness, these should be limited and narrowed down, respectively.

Conclusion and Limitations: Intersection AEB is effective in reducing LTAP/OD and SCP accidents and mitigating injuries However, intersection accidents are highly diverse and accurate performance evaluation requires taking variations into account. The simulations were conducted using ideal sensing without processing delays and an ideal coefficient of friction estimation.

Keywords: Intersection; junction; straight crossing path; left turn across path; AEB; accident avoidance; injury mitigation; V2X; market penetration