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DECISION MAKING FOR COLLISION AVOIDANCE SYSTEMS CONSIDERING A FOLLOWING VEHICLE

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ABSTRACT–In vehicles with driving assistance systems, the responsibility of driving still lies with the driver. Therefore, active safety systems follow a design principle of avoiding intervention as long as possible. Decision making using this principle requires collision avoidance with surrounding objects during the evasive maneuvering of an ego vehicle. However, general decision-making methods for collision avoidance focus on preventing collisions with objects in front of the subject vehicle; the risk of collision with the following vehicle caused by emergency braking is not considered. This paper presents decision-making methods for such collision avoidance systems, wherein emergency braking and steering are considered as collision avoidance maneuvers. The risk of collision is predicted based on the braking model of a normal driver and several emergency braking strategies are designed to avoid collisions. A within-lane steering avoidance method to improve avoidance performance in small overlap collision scenarios and a general avoidance method of steering to change lanes are designed. Collisions with surrounding objects can be avoided using the designed evasive maneuvers; further, maneuvers that can be implemented at the last moment are determined. The results of computer simulations indicate an improved collision avoidance performance using the proposed methods.

KEY WORDS : Emergency braking, Emergency steering, Decision making, Collision avoidance, Following vehicle

1. INTRODUCTION

The intelligent vehicle market is growing rapidly owing to increased customer demand and the efforts of the industry to improve road safety. In particular, the incorporation of autonomous emergency braking (AEB) systems is increasing drastically because of the demands of the New Car Assessment Program (NCAP) and the safety regulations in each country. Euro NCAP has gradually expanded the AEB test scenario from car-to-car in 2014, car-to-pedestrian in 2016, car-to-bicyclist in 2018, to intersection-and-reverse in 2020 (Euro NCAP, 2017). In United Nations Economic Commission for Europe World Forum for Harmonization of Vehicle Regulations (WP.29), a bill mandating the installation of a car-to-car AEB system for commercial vehicles was passed in 2017; it is currently being implemented in the EU. In 2019, a bill mandating the installation of car-to-car and car-to-pedestrian AEB systems for passenger vehicles was officially adopted (ECE/ TRANS/WP.29/GRVA, 2019); it is currently being expanded to target cyclists.

The installation of an AEB system can reduce collisions at low speeds by 38 % (Fildes *et al*., 2015); further, according to the European Commission, it is expected to save more than 1,000 lives per year in the EU. The AEB system has the potential to avoid or mitigate collisions; furthermore, the introduction of autonomous emergency steering (AES) systems is expected to further minimize accidents and deaths. For an accident with vulnerable road users (VRUs), such as pedestrians and cyclists, and with small overlap collisions, the performance of collision avoidance can be improved by emergency steering. German in-depth accident study data show that, in pedestrian accidents, ~ 40 % of accidents occur where the collision location is within 0.6 m to the right in front of the vehicle (Braeuchle *et al.,* 2013). Such frontal collisions with a small overlap account for 15 % of all car accidents and 25 % of all car accidents involving a frontal collision (Kuehn *et al.*, 2013); this amounts to 10 % of the killed and seriously injured (KSI) metric in small overlap collisions and the KSI of VRUs accounts for 36 % (STATS 19, 2015). Euro NCAP suggests the possibility to stimulate the uptake of AES technologies and verify their performance by including them in a rating scheme based on dangerous scenarios that cover a range of road users and interactions. As the first step, Euro NCAP plans to include driver-initiated, within-lane steering support technology in the overall ratings in 2020 (Euro NCAP, 2017).

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