# Study on Active Crash Avoidance Performance by Emergency Braking System.

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## I. INTRODUCTION

Driver assistance systems (DAS) and active safety systems have for some time been active topics of research and development. One of the developments in active safety systems is Autonomous Emergency Braking (AEB) systems which can provide collision warning and emergency braking. Several automakers have already commercialised AEB systems in their products and many others are performing research to introduce AEB and advanced features. These systems are believed to reduce the risk of crash accidents and improve vehicle safety. Although many research results on collision mitigation and avoidance systems have been published, little has been published on collision avoidance and mitigation systems which are similar to the decision-making and driving characteristics of the human driver. [1-4] This paper introduces the AEB system and proposes a control algorithm of AEB systems which has tuned parameters using manual-driving data. The proposed control algorithm was verified and analysed through computer simulation and vehicle tests for New Car Assessment Protocol (NCAP) scenarios

## II. METHODS

### *Overview of Emergency Braking System*

An emergency braking system is a representative active safety system that has functions to avoid crashes between the subject vehicle and frontal object, and to mitigate impact damage in emergency situations. As shown in Fig.1, this system is comprised of a radar sensor, camera sensor, AEB controller, braking actuator and a Human Machine Interface (HMI). The radar sensor detects the frontal object and the camera sensor classifies the frontal object. The AEB controller recognises the vehicle and pedestrian by using radar and camera sensors, and monitors the collision hazard between the subject vehicle and frontal object. Based on a situation analysis, the AEB controller generates a collision warning and braking command depending on various criticality stages. Finally the braking actuator generates a hydraulic braking force and the subject vehicle decelerates and reduces the vehicle speed.

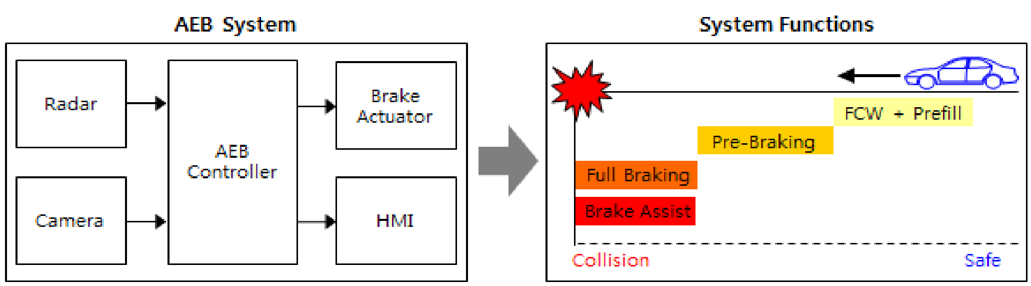


Fig. 1. Block diagram for an Autonomous Emergency Braking (AEB) system.

### *Control Algorithms*

Since AEB systems always work with a human driver, they can be useful and acceptable to the driver. The goal of this system is to allow the driver enough time to avoid the crash and yet avoid annoying the driver with satisfying performance of collision avoidance and mitigation. Fig. 2 shows a scheme of a proposed control algorithm. As shown in Fig. 2, several indexes were used to determine an appropriate warning / braking intervention timing and calculate the braking command: time-to-collision (TTC), required deceleration, in-path probability (Position & Overlap). When indexes are satisfied with the specified condition based on a threshold value, the collision warning and braking intervention would be generated. To improve the driver acceptance

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and satisfy performance, it is important to tune the parameters in AEB systems. In this study, the threshold values of each index are determined by analysis results of human drivers.

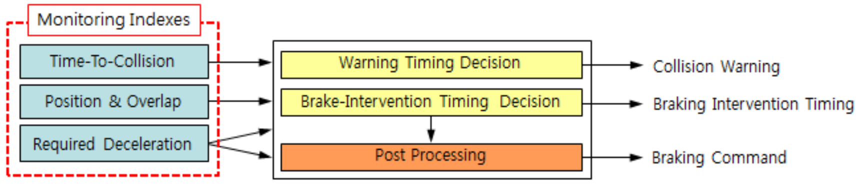


Fig. 2. Block diagram for control algorithm in Autonomous Emergency Braking (AEB) system

## III. INITIAL FINDINGS

An emergency braking system with the proposed control algorithm was evaluated and analysed through computer simulation and vehicle testing. The emergency braking system was implemented and tested in the AEB protocol of Euro NCAP. To validate the performance of the system, test scenarios for a stationary target and low-speed driving target were used. Test results for the stationary target are shown in Fig. 3. In case the velocity of the subject vehicle was below 50(km/h), the system can prevent the collision between the subject vehicle and the frontal vehicle. In case the velocity of the subject vehicle is over 50(km/h), the system mitigate the collision between the subject vehicle and the frontal vehicle. It has been shown that the emergency braking system can provide crash avoidance/mitigation performance depending on the velocity of the subject vehicle and relative velocity.

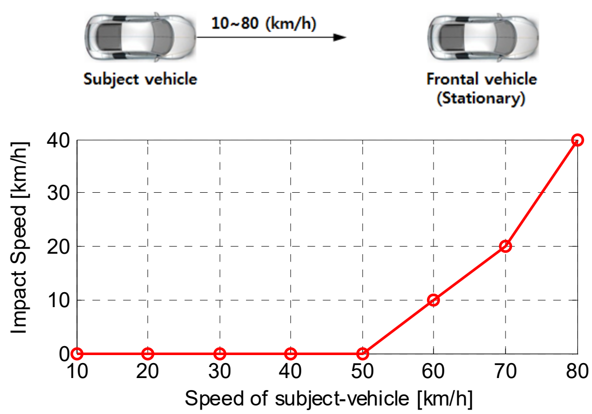


Fig. 3 Crash avoidance & mitigation performance for stationary

## IV. DISCUSSION

In this study, a control algorithm of the AEB system was proposed to investigate the performance for crash avoidance. The control algorithm of the emergency braking system was designed to satisfy the required performance for collision warning and avoidance with improved driver acceptance. To simultaneously ensure driver acceptance and performance, the parameter values were determined based on manual driving data, including those in normal driving and severe braking situations. The emergency braking system can be a good solution for enhancing vehicle safety and driver acceptance. Integration between the passive safety systems and emergency braking systems is the future areas of our research to extend the applicability of the proposed control method.

## V. REFERENCE

[1] Seungwuk Moon, Control Engineering Practice, 2009.
[2] Philipp Reinisch, Proc of IFAC, 2010.
[3] Taeyong Lee, Int Symp FAST-zero, 2011.
[4] A. Vahidi, et al., IEEE Transactions on Intelligent Transportation Systems, 2003.