Development of Robot Vehicle for Active Safety Evaluation in Cut-in Scenarios

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I. INTRODUCTION

Vehicles with active safety systems are currently being launched on the market. The NCAP is preparing to adopt a system whereby vehicles with an active safety system are awarded points that will go towards the vehicle's star rating. It is acknowledged that a reliable test method for verification should be developed for the active safety device, just as exists for the collision safety test that is routinely carried out by NCAP. The necessary evaluation methods for active safety performance are currently being developed in Europe [1-2].

Alongside the methodology, the target vehicle that can be used in simulations is also being developed. The target vehicle simulates the behaviour of accident-causing vehicles, such as stopping, decelerating and cutting-in. As the active safety vehicle test is the evaluation of the system for avoiding collision in accident situations, it always holds the possibility of collision during testing. Therefore, the target vehicle, while serving as a representation of a real-life scenario, should also be able to protect each system should collision occur during testing. TAccordingly, shock-absorbing material must be attached to the target vehicle, but at the same time the testing vehicle must also be able to recognize the target vehicle as a real one. In this study, the target vehicles were developed to satisfy such specifications. Just as with the unmanned vehicle, they were developed taking into account correct representation of accident scenario, repeatability of test and safety of test driver. Real vehicle testing is then carried out to verify the developed system. For the purposes of this study, the selected test scenarios were decelerating and cutting in, in other words lane change (LC) in front of active safety car.

II. METHODS

Other studies have invested great effort in developing the target vehicle [1], [3-4]. The target vehicle developed for this study was produced by modifying the electric vehicle and installing the unmanned-controlling module. The dynamic performances were increased by lowering total weight of the vehicle by removing all exterior and interior materials. The actuator and controller, such as steering controlling actuator, brake (deceleration) control, acceleration control actuator, speed change actuator, wheel encoder, remote controller, interface module box, control box, interface module box and power supply box, were installed for unmanned driving and remote control.

The steering controlling actuator used MDPS module as the mechanical part that controls the steering of the vehicle. The acceleration and deceleration actuator controls the accelerator pedal with mechanical part and wire. The remote controller can control the power status of the system, the power of each actuator and the operation mode of the system (Fig. 1(A)). A remote control server (Fig. 1(B)) was installed to control the target vehicle, so that the various collision evaluation scenarios could be conducted unmanned. Soft crash was developed to protect the target vehicle during the collision and was installed at the height at which the actual vehicle collides, which is the position of the bumper. As the position of vehicle frontal bumper generally ranges from 220 mm to 720 mm, soft crash was installed at the position suitable for that from 220mm to 720mm. A shock absorber and sponge were also used.

(A) (B)

Fig. 1. (A) Layout of target vehicle, (B) Control server and program.

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III. INITIAL FINDINGS

The real vehicle test was carried out using the developed target vehicle. The AEBS (Automatic Emergency Braking System)-adopted vehicle was selected as test vehicle for the test, and soft crash was attached to it (Fig. 2(A)). The scenario used in the test was carried out at the difference of relative velocity of 10 km/h in the condition of 0, 20, 30, 40 km/h, based on the speed of target vehicle in cut-in situation, and it was programmed to implement cut-in and generate the steering at the time when TTC (Time To Collision) of both hunter vehicle and target vehicle became 4 s in case of cut-in scenario (Fig. 2(B)). Looking at the test result for 40 km/h, it was known that the speed of target vehicle was maintained at 40 km/h and the trigger was generated at the point when TTC of testing vehicle was 4. It was observed that TTC increased in a moment, due to braking of testing vehicle, at 30 s . In terms of the change of steering angle, it was observed that steering began at the same time of generation of trigger and cut-in was completed after 3.5 seconds (Fig. 3).

(A) (B)

Fig. 2. (A) Active safety car test environment, (B) Cut-in scenario for the test.

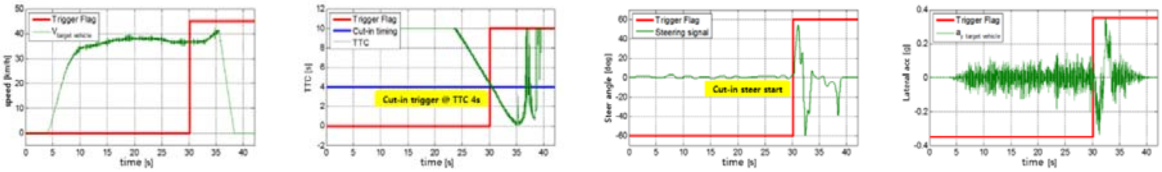

Fig. 3. Test result at target speed 40 km/h.

IV. DISCUSSION

The results obtained show that the AEBS of the testing vehicle commenced approximately 5 s after target vehicle began to cut in, but this performance was already known. It was also already known cruise driving of target vehicle could be performed well at 35–40 km. The objective for the target vehicle in this study was to perform correctly and consistently under repetition, but it was expected that this would be the case. While it did cut-in at TTC 4 s and finished cut-in at TTC 3.5 s,it was, however, too slow at cutting-in. The TTC at cut would need to be reduced to produce a more realistic accident situation, and it was considered that a faster cut-in could be achieved by increasing the steering angle. Additional performance improvement of the target vehicle and more precise speed control would be required to achieve that.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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