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Effectiveness of Lane-Keeping Control using Driving Assistance Torque under Tire Blowout

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In recent years, the number of traffic accidents caused by tire blowout has been increasing on highways. A tire blowout causes a decrease in tire radius and cornering stiffness. Vehicle dynamic characteristics change rapidly caused by the tire blowout. It is difficult for drivers to maneuver the vehicle with blown-out tire keeping the lane. Therefore, a lane-keeping assistance system under a tire blowout is needed to improve safety. However, few studies of the lane-keeping assistance system under a tire blowout have been researched. In this paper, a lane-keeping control system under a tire blowout was proposed and an effectiveness of the lane-keeping control system were investigated.

The proposed system is shown in Fig. 1. The lane-keeping control system supports the driver's steering behavior by the assistance torque. To evaluate the proposed driving assistance system, a lateral deviation of the vehicle, an angle of the steering wheel, and gaze points of the driver were measured by the driving simulator experiments. The experiments were carried out to confirm an effectiveness of the proposed steering assistance system by twenty participants. The driving course had an environment that simulated a highway (straight section) with two lanes on each side. The driving simulator was set to keep a constant speed (100 km/h) automatically without accelerating or decelerating. Drivers were instructed to maneuver only the steering wheel and to keep driving in the left lane. The driving test of 45 seconds each time was carried out. There were 6 driving conditions in the experiments. ((1) Normal running condition without the tire blowout and the control, (2) Tire blowout condition without the control, (3) Tire blowout condition with the control (Control Condition I: middle assistance torque), (4) Tire blowout condition with the control (Control Condition II: large assistance torque)), (5) Tire blowout condition with the control (Control Condition III: small assistance torque)), (6) Tire blowout condition with the control (Control Condition I: middle assistance torque and large dead time)). Fig. 2 shows the lateral deviation from the center of the lane after the right front tire blowout (solid line: with control, dashed line: without control), and Fig. 3 shows the P-P values of the lateral deviation during 10 s after the right front tire blowout. The median value of the P-P value (Fig. 3) of the lateral deviation of the vehicle decreases about 1.0 m by the lane-keeping assistance system. The experimental results showed that a lateral deviation of the vehicle was able to be reduced by the steering assistance system. The risk of a lane departure under the tire blowout was able to be reduced by the system. On the other hand, it was also confirmed that increasing the assist torque might lead to miscommunication between the driver and the assist system based on Fig. 4.

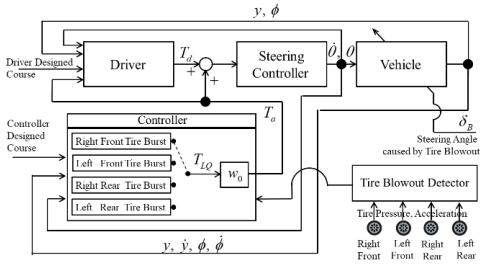

Fig. 1 Lane-keeping Assistance System after Tire Blowout

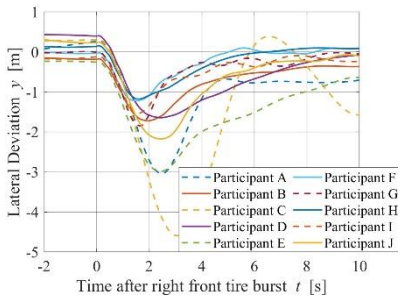

Fig. 2 Lateral Deviation after Right Front Tire Blowout

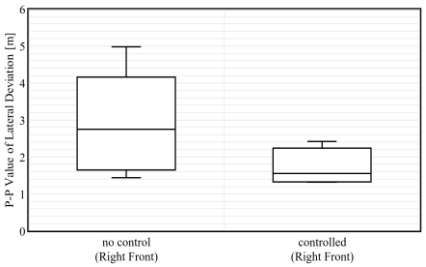

Fig. 3 P-P Value of Lateral Deviation (Right Front Tire Blowout)

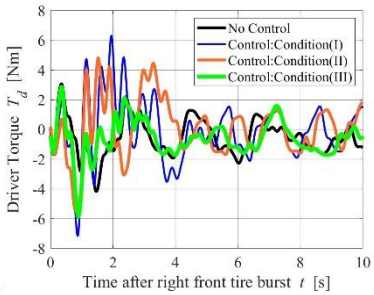

Fig. 4 Steering Torque of Participant I