Human Factor Research Using a Driving Simulator

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ABSTRACT
Two recent topics on human factor research using a driving simulator are introduced. One is evaluation of driving comfort by activity of sternocleidomastoid (SCM) muscle of a passenger, and the other is evaluation of human-machine interface for an automatic platooning truck. To examine human responses, it is essential to carry out experiments since it is hardly possible to make a model of human behavior for numerical simulation. In both researches, driving simulators are utilized to conduct the experiments with safe and ease. The meaningful results are obtained in both researches through the experiments using the driving simulators.

1. Introduction
In the field of automobile engineering, higher importance is placed on human related topics such as comfort, human-machine interface, and safety. It is demanded to carry out human factor researches. As it is difficult to express human behaviors with some mathematical models, we need carry out experiments including humans. Although an experiment using a test car is one of the best methods, it brings risk of accidents. Then a driving simulator is utilized to analyze behaviors and responses of drivers and passengers. Two recent researches on human factor using driving simulators are introduced. The first one is evaluation of driving comfort by activity of sternocleidomastoid (SCM) muscle of a passenger. As SCM is a muscle to keep position of the head, electromyography (EMG) signal of the SCM increases when the unwanted lateral acceleration grows. Usually an automobile having poor driving comfort produces unwanted lateral acceleration when it is steered, thus the comfort can be evaluated with the amplitude of the EMG signal. The effectiveness of the proposed method is examined through experiments using test cars and a driving simulator. The second one is evaluation of human-machine interface for an automatic platooning truck. This research is carried out as a part of project of Development of Energy-saving ITS Technology, financially supported by New Energy and Industrial Technology Development Organization of Japan (NEDO). Driving environment of a cabin of the truck under automatic platooning control is reproduced on the driving simulator. Then human-machine interface of the controller for the automatic platooning is evaluated on the driving simulator. Through introducing these two research topics, direction of the human factor research on the automobiles and significance of the driving simulator in the research topic are discussed.

2. Evaluation of driving comfort
The possibility to use passenger’s EMG of SCM muscles as an objective evaluation indicator to vehicle dynamics is discussed. The SCM is in the neck, and its main function is keeping the head in the appropriate position. Two same cars are prepared for the experiments. One is the normal car, and the other is the modified car, whose body is reinforced to increase its rigidity. While the test cars were driven at the speed of 65km/h in a slalom course of 30m intervals, the EMGs of 5 subjects were measured as well as the relative acceleration in the car body. Figure 1 show RMS value of EMG signal of SCM muscle of all subjects. The RMS of the EMG in the modified car is significantly smaller than the normal car.

![Fig. 1. RMS values of the EMG signals for SCM muscles in the test car experiments (mean ± S.D., and two-sample paired t-test: *P < 0.05 and n = 5).](image)

The motion of the test car in the slalom course is reproduced in the driving simulator (DS), as shown in Fig. 2. Four motions are produced by adding the relative accelerations of the normal car (normal 100%), two times of it (normal 200%), the relative accelerations of the modified car (modified 100%), and two times of it (modified 200%). The EMGs of the SCM of 10 subjects are measured on the DS. As shown in Fig. 3, RMS value in the modified car significantly lower than the normal car (P < 0.05 and n = 10).

![Fig. 2 Photograph of the driving simulator.](image)
Fig. 3. RMS values of EMG signals in the DS experiments (mean ± S.D., and the two-sample paired t-test: *P < 0.05 and n = 10).

3. Human-machine interface of the controller for the automatic platooning truck

Human factors in automatic platooning are mainly about operations and conditions of driver during the processes of the formation and separation of the automatic platooning. Otherwise, it is also necessary to evaluate human-machine interface for the communication of driver and the system of the automatic platooning. As a novel technology in automobile field, a driving simulator for trucks is used for evaluate automatic platooning driving and its system considering human factors. A truck driving simulator, as shown in Fig. 4, was developed. In whole, a full-scale cabin of a real truck, steering equipment attached a servo-motor, an air seat, a sound generator based on the actual-vehicle driving of truck and control software are integrated into a driving simulator system to improve driver sense in a truck driving. TruckSim software, linked with Simulink, is connected with the host computer of DS using dSPACE. Then the Gap distance control and path following control for automatic platooning and adaptive cruise control (ACC) utilized for the actual platooning trucks, were built in the DS.

Fig. 4 The DS for the platooning truck.

For the application of the automatic platooning, three types of human-machine interface (HMI) are designed: numeric characters, graphics, and numeric characters & graphics types. Ten full-time truck drivers are cooperated in our study, for evaluation of HMI system. The mean age is 44.3 years old, license experience for truck is 15 years, driving experience of truck is 9.2 years, and driving frequency of truck is 41.2 hours/week. The subjects are asked to rank the three types of HMI system and to evaluate the information provided by the HMI system. The most popular display is that using both numeric characters and graphics, because its contents can be easily understood to master the driving conditions during the automatic platooning. The information items highly rated are control status of own truck by figure, current velocity, current gap distance, target gap distance, and number of trucks in transmission, which are closely related to safety. To the contrary, the drivers paid few attentions to the items of current acceleration, target acceleration, and instantaneous fuel economy.

Fig. 5. Three types of HMI; Information is given with numeric characters in (a), graphics in (b), and both numeric characters and graphics in (c).

4. Conclusion

Two research topics are introduced. One is evaluation of driving comfort by activity of sternocleidomastoid(SCM) muscle, the other is evaluation of human-machine interface of the controller for the automatic platooning truck. In both researches meaningful remarks are derived from the DS experiments. The driving simulator will remain important as a tool to examine the human factors in the field of automobile engineering.

References