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主　論　文　の　要　旨

論文題目　**Driver state estimation by using graphical-based model toward advanced driver assistance systems (先進運転支援システムのためのグラフィカルモデルによるドライバ状態推定)**

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論　文　内　容　の　要　旨

Human factors and ergonomics is a study for the design of products, processes, and systems which utilizing the theory and application of both psychological and physiological principles. The field is interdisciplinary of psychology, engineering, biomechanics, industrial design, physiology, user experience, and so on. The goal of human factors is to reduce human error, increase productivity, and enhance safety and comfort focusing on the interaction between humans and the specific device or machine. As automobiles started to widely use in the 1900s, the increasing number of car accidents started to get attention. As a consequence, human errors and human characteristics in such accidents have been studied and later human factors were introduced to the automobile design.

Human factors in vehicles firstly focused on the vehicle mechanical design for the ergonomics such as steering wheel shape and position, gas/brake pedal position, driver seat comfort, and the body design to reduce the blind spot of driver. Up until now, the study on foot position to prevent misapplication is still a concern for researchers due to the differences between regions and areas. When the design and user interface of the vehicle becomes standard, the driver experience and feeling started to draw the attention of the automaker and researchers. Driver state estimation also gains its position in the human factors for automobiles. Driver state estimation does not only

allow to analyze the results of the interaction between human and vehicle, but the principles of the methods or models using to estimate the human state can also provide additional knowledge for further improvement of the system.

At present, driver state estimation covers a large range of human states including fatigue, workload, stress (both physical and mental), and arousal level. The sources for these states originate from many factors such as ages, genders, driving experiences, jobs, driving time, and health conditions. Using driving-based performance (headway information, risk potential or estimation, lane deviation, or steering operation, etc.) have been studied to detect abnormal states of drivers. Another approach is from the biomedical field, in which the physical condition of the driver is measured and analyzed. Invasive and non-invasive sensors are attached to the driver to monitor the changes of the human body in various driving conditions and psychological conditions. The problem with this approach is difficult to apply to practical use. So that non-invasive and mobile devices and robust monitoring methods have been intensively studied for the last decade. The above methods still have many limitations such as sensitivity to the threshold in driving-based performance or noise from the movement artifact in real driving.

In the search for developing an advanced driver assistance system to help the driver in case of incapable to operate the vehicle safely, especially in an emergency situation (heart attack or similar) we have come with a concept that proved working. But there have been many limitations and obstacles which need to be solved to make the concept practical. By reviewing many pieces of research and publications in various related fields, we aware that preventing the emergency situation is not only at the trigger time but needs a long period of monitoring the driver's condition. And thus, continuous driver state estimation plays an essential part in the concept system.
The purpose of this dissertation is to adopt the graphical model to estimate the driver state, the exploratory character of the model can help to identify the interaction of the system components which are human internal state and driving operation, and the driver state can also be estimated at the same time. The model was successfully applied to detect driver surprise state in case of simulated driving misoperation. The preliminary results of the other experiment also showed that the same method can be used to detect driver drowsiness. The author also proposed a strategy to overcome some limitations of the mentioned driver assistance system.

The dissertation is organized as follows: Chapter 1 describes the introduction of the background of traffic accidents. The author provided a brief summary of the cause of traffic accidents and the driver assistance system. Chapter 2 brings up various methods

and techniques for driver assessment, from the objective methods to subjective methods. The advantages and disadvantages of the methods were presented and discussed.

In Chapter 3, the author presented a study of a real-world driving experiment. The experiment was taken placed in a test track, sensors were attached to the subjects to measure the physiological indices, driving data was recorded at the same time and factorial analysis was conducted to see the effects of driving tasks, driver skill, and driver states on the driving performance and physiological indices of the subjects.

Chapter 4 provides the background of the graphical models. The fundamental of directed and undirected graphical models was presented. The advantages of the Gaussian graphical models in exploring the interaction of complex system has also been discussed.

In Chapter 5, the graphical model has been adopted to develop a graphical-based model to detect the surprise state of the driver in case of pedal misapplication. Subjects were asked to conducted driving in normal conditions and a simulated error was created by the operator to create the surprise situation. By collecting driver physiological data and driving data, the model can detect the driver state with high accuracy and low false rate. The information inference acquired from the model also provided additional supporting information for explaining the interaction between human reaction and the alert system.

Chapter 6 presents the study on drowsiness detection. The preliminary result showed the possible apply the graphical-based method on the gradual event while driving.

In Chapter 7, a concept of the driver assistance system during the emergency is presented. In this concept, the authors described the components of the system with their parts. A demonstration was conducted in a well-designed situation to check the feasibility of the system. Even though there were still some limitations at the time of the proposal, the concept has proven that the system could detect the emergency state of the driver and safety stop the vehicle. The graphical-based model proposed in abrupt/surprise events and gradual events can be used as an important part to improve the effectiveness of the system.

Chapter 8 concludes the dissertation and presents the remarks of future work.