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A Study on Stress Estimation of Car Drivers Based on Facial Image Analysis

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In the driving environment, it is necessary to manage driver's mental condition stably. As one of solution, the estimation and measurement method of driver's stress will be effectiveness. However, direct measurement method of biological signal such as heart rate, brain wave also has inconvenience to attach the measurement device onto driver's body during driving. In this study, use of visual information acquired through the camera which can be install easily inside the vehicle has been examined. In particular, estimation technique for driver's stress through the facial image processing has been developed based on the relationship between blood flow and color component of facial image.

In this report, fundamental system of image processing and driving simulator to conduct the experiments to verify the proposed system have been constructed. For image processing system, color component decomposition and time series analysis method has been implemented using Python. And the driving simulator was constructed based on Unreal Engine with Roadrunner provided by Mathworks Inc. As driving environment on the simulator, one normal course as Course-A and two courses with event for driver's distraction as Course-B and C were prepared to induce the driving stress for subject drivers. The details of two types of events implemented in this system as Course-B and C were follows.

Course-B: A road environment with four oncoming lanes that is continuously uphill and downhill for a long period of time.

Course-C: A road environment with four oncoming lanes with some parts of lane restrictions by color cones.

As the experiments, 4 subject drivers were participated, and they were asked to drive in each course with 100km/h of vehicle speed and travel time of 15 minutes. During the experiments, facial movie with ring light under the protection from environmental light and electrocardiographic (ECG) from body surface of subject driver were acquired as time-series data. After the experiments, following analyses were conducted.

The facial movie were divided into frame images, and the average value of the green component of intensity for all pixels was calculated. On the other hand, the R-R interval (RRI) data was also calculated using the analysis software HRV24Calc as attached with measurement device of ECG. RRI values calculated in unequally period were resampled by the moving average minutely.

From the previous study, the rate of change of RRI less than 100% means a state of stress of participants. It will also make changes of blood flow including blood hemoglobin which has characteristics of absorption for green component of three primary colors of light. In other words, it has a possibility to estimate the state of stress if the change in RRI could be observed by the change in the green component of the subject's facial image.

In order to evaluate the relationship between the acquired data, correlation analysis between the RRI and the time series of the green component have conducted. As the results, the correlation coefficients ranged from -0.2 to -0.7 were obtained. From these results, it is confirmed that the tendency for a negative correlation between the green component of facial images and the RRI. However, these trends were not uniform among the all subjects in this paper.

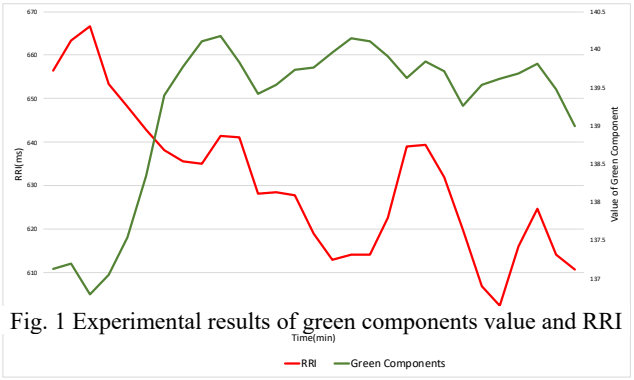

Fig. 1 Experimental results of green components value and RRI

In this paper, experimental system and analysis process of our proposed method have been described and its validity was examined through the experiment. The results show the possibility of estimation for driver stress by the facial image. And it is also confirmed the necessity of verification of estimation accuracy through the analysis for the relationship with the stress state in detail using LF/HF values as heart rate variability analysis. It is also necessary to examine the validity of the trends observed by increasing the number of subjects.