K. Nakano Lab

Mobility Engineering Using Bio-signals

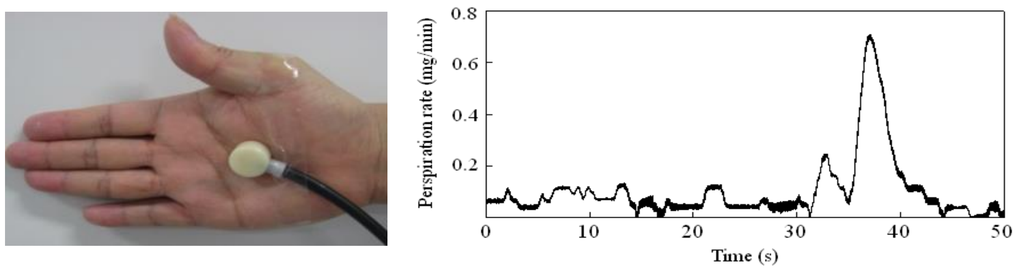
Partner : JTEKT Corporation, Suda Lab
Fund: NEDO

Background

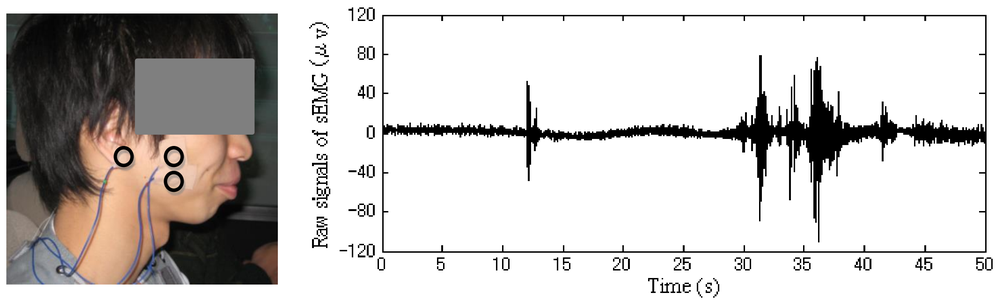
Insight into human-machine interaction is a critical topic with the large-scale development of intelligent vehicles; meanwhile, bio-signal analysis can provide a deeper understanding of driver behaviors that may indicate rationally practical use of the automatic technology. Therefore, this study concentrates on biosignal analysis to quantitatively evaluate mental stress of drivers during automatic driving of trucks.

Bio-signal Measuring and Processing

Palmar perspiration rate and surface electromyography (EMG) of masseter muscles were measured during driving experiments, and a bio-signal processing was proposed to evaluate mental stress of each participant. After the steps of rectification, five-point moving average, and normalization of the collected bio-signals, root-mean-quad value was calculated as stress intensity.



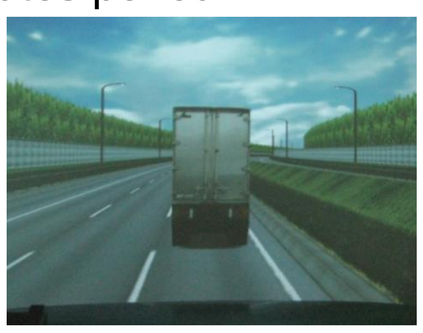
Palmar perspiration rate measuring and its signals



Masseter muscle and its EMG signals

Experimental Scenarios

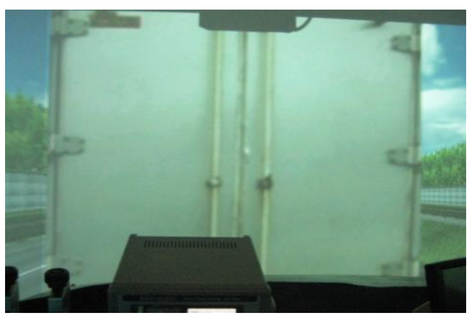
Four car-following experiments were prepared: manual driving in which drivers were asked to keep a gap distance of 20–30 m from preceding vehicle, and three automatic driving with automatically keeping of gap distances of 4, 8, and 12 m from the preceding vehicle. In both manual and automatic driving, the preceding vehicles were programmed in a randomized place and time point to decelerate without notice from 80 to 30 km/h during a 2.5 minutes period.



25m gap distance

12m gap distance

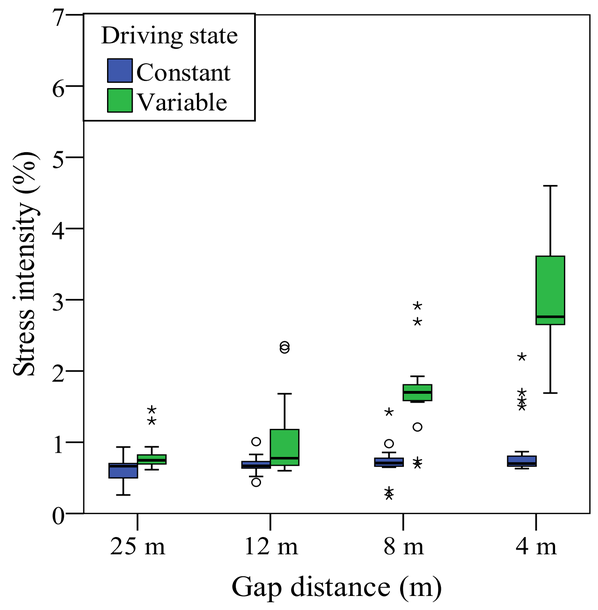
8m gap distance



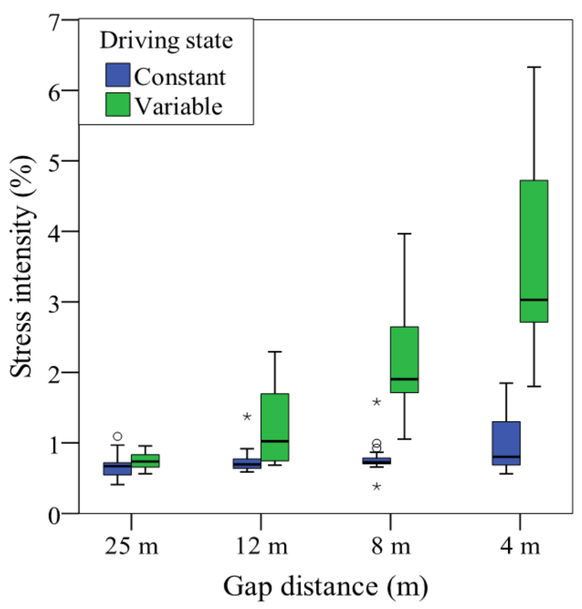
4m gap distance

Results

By a two-way repeated measures ANOVA with two variables (driving state × gap distance), there were a significant main effect of the driving state ($p < 0.001$), indicating that stress intensity was significantly higher for the variable condition than for the constant condition, and a significant main effect of the gap distance ($p < 0.001$), indicating that stress intensity was significantly different for the gap distances of the 25 m,12 m, 8 m, and 4 m. More importantly, a significant interaction was found between the driving state and gap distance ($p < 0.001$).



Results from palmar perspiration



Results from masseter EMG

Conclusions

On the purpose of identification of driver state during automatic driving of trucks, mental stress of drivers was successfully evaluated through biosignal analyses in a driving simulator experiment.

Publications:

Zheng R., Yamabe S., Nakano K., Suda Y., 2015, Biosignal Analysis to Assess Mental Stress in Automatic Driving of Trucks: Palmar Perspiration and Masseter Electromyography, Sensors, 15-3, pp. 5136-5150, DOI:10.3390/s150305136.