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Modeling of Passenger Vehicle Ride Comfort Based on Bio-Signals and Emotion Theory

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Recently, prediction technology of ride comfort of passenger vehicle have received increasing attention, as various automatic driving systems have been developed. In this study, the prediction model of ride comfort from various measurement sensor data has been developed using Machine Learning algorithms. The scheme of the present model is described in Fig.1. The measurement data including vehicle acceleration in each direction were used as explanatory variables, and the vectorized emotion scores from the questionnaire results and the bio-signals including the electrocardiogram and the pulse wave of the passengers were used as objective variables. The vehicle acceleration and bio-signal data were transformed to time-frequency data by Wavelet transformation. As evaluation of ride comfort, we have adopted the two-dimensional circumplex emotion model proposed by Russell(1).

Figure 2 shows the emotion scores including pleasurable/unpleasurable and subduing/exciting in the conditions of 15/25mm speeds bump with various constant speeds. Obviously, the arousal score increases with vehicle speed in all “no blind conditions” whereas the valence scores are stable. On the other hand, in each “blind condition” the arousal increased but the valence scores declined (deterioration) with the speed. This indicates that the visual information significantly affects the ride comfort in addition to the vehicle acceleration.

In this study, various machine learning models including Support Vector Machine (SVM), Artificial Neural Network (ANN) and Random Forest Regressor (RF) were constructed and compared using R2 scores. As a result, RF model was adopted for the bio-signal prediction. The regression characteristics of ECG, RRI and pulse from the vehicle accelerations are shown in Fig.3. Each predicted value agrees well with the actual measuremt, suggesting that the bio-signals of passengers have clear correlations with the acceleration. In addition, the correlation between the bio-signals and the ride comfort scores using the emotion theory has been analized and discussed. The present model makes it possible to predict the ride comfort more accurately from CAE (Computational Aided Experiment) or actual measurement data.

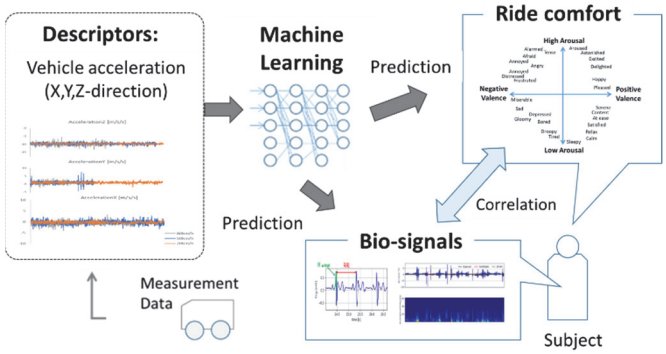

Fig.1 Present scheme of ride comfort prediction

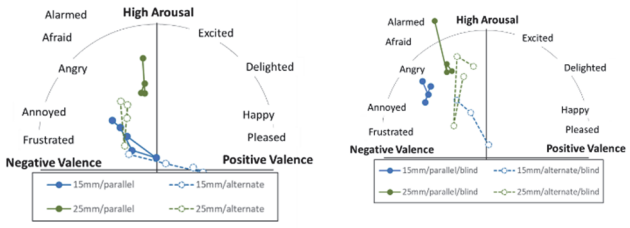

Fig.2 Emotion scores of a passenger based on Russel’s model in various bump height and vehicle speeds in “no blind condition” (left side) and “blind condition” (right side).

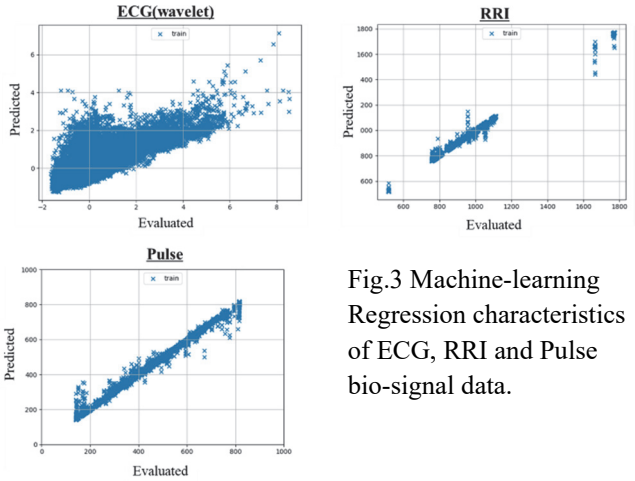

Fig.3 Machine-learning Regression characteristics of ECG, RRI and Pulse bio-signal data.

(1) J. A. Russel: A circumplex model of affect, Journal of Personality and Social Psychology, 39, pp.1161 (1980).