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A Machine Learning Approach Analyzing Mechanism of Carbon Dioxide Emission from a Hybrid Vehicle in Real Driving

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For future CO_2 emission reductions from automobiles, the challenge is to reduce CO_2 emissions in the real world. In the real world, CO_2 emissions in the real world are influenced by various factors and are very complex, and it is not easy to properly evaluate the effects of these factors and the emission mechanisms are not still clarified. Hybrid vehicles have high thermal efficiency and fuel economy by using both a motor and an engine to compensate for the disadvantages of engines. Accordingly, the CO_2 emission mechanism of hybrid vehicles is expected to be more complex than that of gasoline vehicles. However, there are few studies on about CO_2 emissions of hybrid vehicles in the real world. Therefore, this study aims to clarify one aspect of the CO_2 emission mechanism of a hybrid vehicle by analyzing the influence of various factors on instantaneous CO_2 emissions for on-road driving data.

The real world HEV driving data in this study were provided by HORIBA, Ltd. The vehicle is a C-segment passenger car, weighing 1.5 tons and powered by a 1.5 L naturally aspirated engine. GPS (Global Positioning System), PEMS (Portable Emission measurement system), and OBD (On Board Diagnostics) were used to measure various data in this test.

Two instantaneous CO_2 emissions prediction models were constructed using LightGBM[(1)], a machine learning method based on decision trees. The difference between the two prediction models is whether the data used is the entire trip data or limited to instantaneous CO_2 emissions. SHAP[(2)] (SHarply Additive exPlanations) was then applied to each prediction model and the mean SHAP value was calculated to understand the influence of the features used as inputs on the model's predicted outcome. In the model for the overall driving data, the mean SHAP values for road gradient and the amount of accelerator pedal were particularly high. On the other hand, in the model for the data limited by instantaneous CO_2 emissions, the mean SHAP values were higher for the amount of accelerator pedal, speed, and acceleration, in that order. These results suggest that the scenes in which the engine is running can be identified by analyzing and comparing data for the entire trip data and data limited by CO_2 emissions.

The factors with the high mean SHAP values were tracked over time. As a result, it became clear that the engine was running and CO_2 emissions occurred because the vehicle stopped and started where there was a road gradient during this road trip. Future issues include the need to analyze the effects of factors that were not considered in this study by measuring more items of the surrounding environment and road information, such as road curvature. In addition, it is necessary to consider the length of the time range for time tracking of information on surrounding traffic flow, such as vehicles ahead, when conducting real-world time-series analysis.

(1) Ke, G., Meng Q., Finley T., Wang T., Chen W. Ma W, Ye Q. Liu, T., “LightGBM: A Highly Efficient Gradient Boosting Decision Tree,” Advances in Neural Information Processing Systems, 30(2017)

(2) Scott Lundberg and Su-In Lee, “A Unified Approach to Interpreting Model Predictions”, arXiv:1705.07874 (2017)

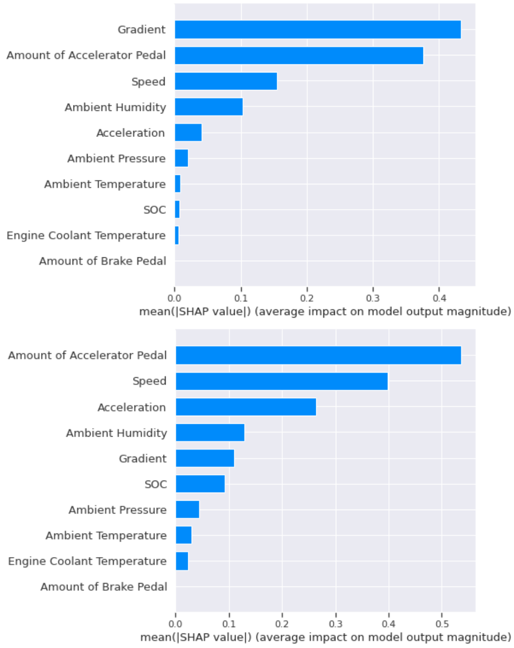

Fig.1 Mean SHAP value for the models
Upper: all data, Bottom: limited

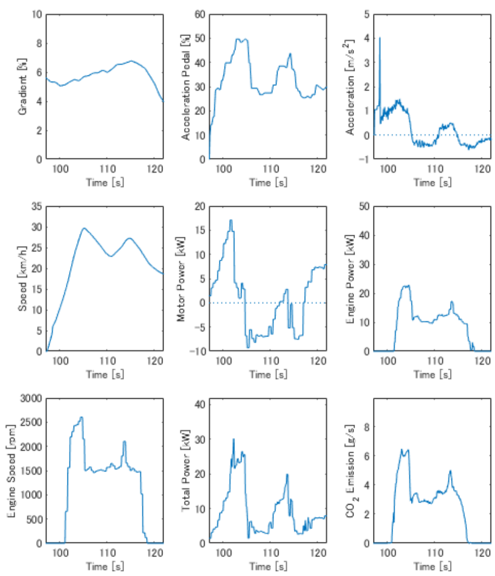

Fig. 2 Time variations of each feature

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