Driving aggressiveness in hybrid electric vehicles: Assessing the impact of driving volatility on emission rates

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Hybrid electric vehicles (HEV) have demonstrated energy benefits to road traffic networks, but a deeper understanding the correlation of driving volatility with their energy use and pollutant emissions is rather rare. This paper introduces an approach based on driver volatility measured by vehicle acceleration and vehicular jerk (first derivative of the acceleration) to estimate HEV emissions rates. Dynamic emission models represented by nine driving behaviors associated with vehicular jerk classification and considering the on/off state of the internal combustion engine (ICE) are proposed. To assess real-world emission performance, data were collected from one vehicle using a portable emissions measurement system.

Results indicated that proposed models using engine speed as input were good predictors of carbon dioxide and particulate matter (R^2 ranged from 0.72 to 0.96, depending on the pollutant and vehicular jerk type) for both internal combustion engine on/off states. However, the predicted emissions of nitrogen oxides resulted in values of R^2 lower than 0.57, mostly due in part to the proportion of measured concentrations lower than the instrument detection limit (~47%). Driving volatility-based models accurately characterized measured carbon dioxide (with 1–16% of measured value) and yielded lower relative mean square errors than the traditional vehicle specific power modal approach.

These results suggest that vehicular jerk classification can be useful to reduce instantaneous emission impacts during different driving regimes. For instance, these models can be integrated into electronic car units to provide feedback about emission rates associated with volatile driving and into warning systems that could detect/prevent unsafe maneuvers. These classifications would allow for better energy efficiency and eco-efficient driving behavior controls for automated vehicles.

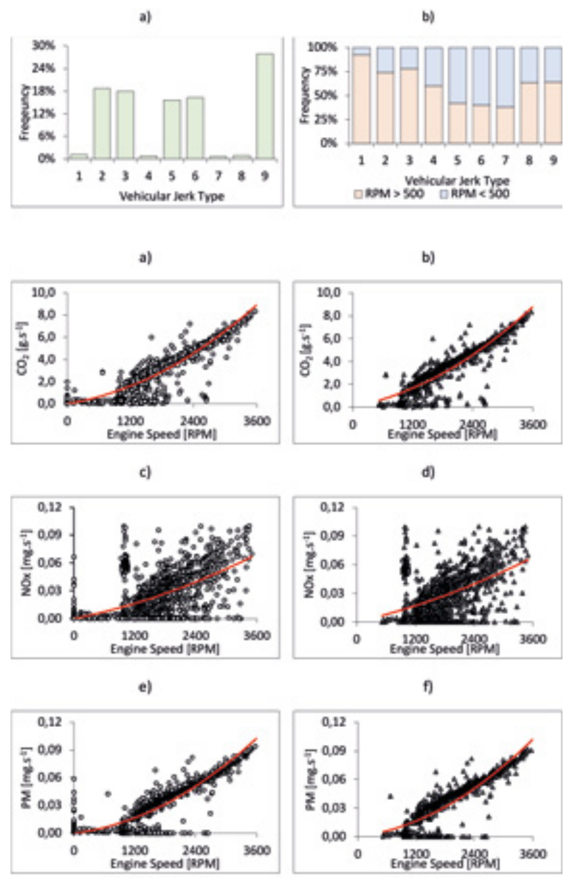

FIGURE 1
(upper) Time distribution by vehicular jerk type using the training dataset: a) percentage of time using all ICE on/off data (on – RPM above 500, off – RPM below 500); and b) percentage of time using separated ICE on/off data. (bottom) Speed counter map for vehicular jerk type 9 (cruise speed): a) RPM versus CO_2 with ICE on/off data; b) RPM versus CO_2 with ICE on data; c) RPM versus NOx with ICE on/off data; d) RPM versus NOx with ICE on data; e) RPM versus PM with ICE on/off data; and f) RPM versus PM with ICE on data.