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Application of Deep Neural Networks for Multi-Output Prediction of Performance and Emissions in Propane SI Engines

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The integration of neural networks into internal combustion engine research provides new opportunities for efficient performance evaluation and emission prediction. This study explores the application of deep learning techniques to enhance the evaluation of performance and emissions in internal combustion engine research. A multi-output deep neural network (DNN) model was developed to predict the behavior of a propane-fueled spark-ignition (SI) engine, focusing on key performance metrics and emission characteristics. The dataset was generated using the AVL-Boost simulation platform, encompassing a diverse range of operating conditions by varying parameters such as combustion duration, equivalence ratio and engine speed. The proposed DNN architecture simultaneously predicts multiple engine outputs, including engine performance, engine combustion metrics and emissions (NOx, CO, and unburned hydrocarbons). To optimize training efficiency, four learning rates (0.001, 0.005, 0.01, and 0.05) were evaluated alongside adaptive optimization techniques. Model performance was rigorously assessed using statistical metrics, including root mean square error (RMSE), mean absolute error (MAE), and coefficient of determination (R^2). The evaluation results demonstrated that the DNN model could accurately predict multiple outputs simultaneously, achieving high coefficients of determination ($R^2 > 0.99$) and low mean absolute errors (MAE < 5%) across all output categories. Evaluation of four learning rates shows that learning rate is 0.001 consistently delivers the highest predictive fidelity, with the lowest MAE, MSE, and RMSE, and near-perfect R^2 (99.968%).

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