

Deploying Machine Learning at the Edge for Real-Time Vehicular CO₂ Emission Monitoring

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The global increase in vehicle numbers has a direct impact on vehicular CO₂ emissions, significantly contributing to climate change and calling for the urgent need for innovative solutions. Integrating machine learning into carbon emission estimation offers the potential for accurate prediction, modeling, and analysis of environmental factors that drive air pollution. This paper presents a real-time CO₂ emission monitoring system designed for an intersection within an Internet of Vehicles (IoV) framework. As vehicles pass through the intersection, their models are automatically identified using a ResNet-50-based detection model deployed on the Zynq UltraScale+ ZCU104 platform. The identified vehicle model is then passed to a CO₂ emission model, which calculates the emissions and transmits the data to a central traffic management unit. The collected emission data are then aggregated and analyzed to assess the levels of pollution in the region. We evaluate our multilayer perceptron (MLP) model against Random Forest, Linear Regression, Support Vector Regression (SVR), and K-Nearest Neighbors (KNN) in a SUMO-simulated environment. To enhance interpretability, we apply SHapley Additive exPlanations (SHAP) to identify feature importance. The results show that the proposed method accurately predicts vehicle CO₂ emissions, allowing a more effective pollution assessment.

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