SMART CARBON EMISSION TRACKING SYSTEM FOR SUSTAINABLE LIVING

Project Reference No.: *49S_BE_4532*

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Keywords:
Carbon Emission Prediction, Deep Learning, Sustainable Mobility, Vehicular Emission Analysis, EcoGRU

Introduction:

1. Climate change is posing a huge challenge worldwide and the transportation sector is a substantial contributor to carbon emissions and environmental degradation. The intensive growth of private vehicle use has led to increasing emissions of greenhouse gases, mainly carbon dioxide (CO_2), enjoying air pollution and having adverse effects on public health. While the consciousness on sustainable living is building, people still do not have access to a convenient way to track their personal emissions from transportation as most systems in place are intended for large scale industrial applications and are too complicated for daily consumers.
2. New methods in deep learning have recently made it possible to build predictive models that learn complex dependencies between vehicle parameters and emission levels. Models such as ANN, LSTM and GRU present promising results for the task of emission prediction. In this work, a Smart Carbon Emission Tracking System that approximates the emission quantities with vehicle parameters is presented and an EcoGRU model is proposed that enhances training stability and prediction performance for scalable and realistic emission analysis.

Objectives:

1. To design and implement a system that can estimate for vehicular carbon emissions using vehicle-based parameters.
2. To analyze and preprocess real-life vehicle emission data for building prediction models.
3. In addition, a new EcoGRU model is designed and tested in this paper, which enhances training stability and mitigates overfitting.

Methodology:

1. The project smart carbon emission tracking system for sustainable living is based on a vehicle emission dataset, which includes vehicle type, fuel type, emission norms, and distance traveled. The data is high quality processed by dropping NaN and duplicate values, then selecting features and normalizing.
2. Various deep learning models such as ANN, LSTM, GRU, and the proposed EcoGRU are constructed and trained on the processed data. The proposed EcoGRU model introduces the stacked layered structure, dropout technique, and a learning rate scheduling mechanism into the traditional GRU model to improve the stability of prediction. The model prediction accuracy is assessed with MAE, RMSE, MSE, and R2 values, and the prediction errors are compared to determine the best prediction model for carbon emission.

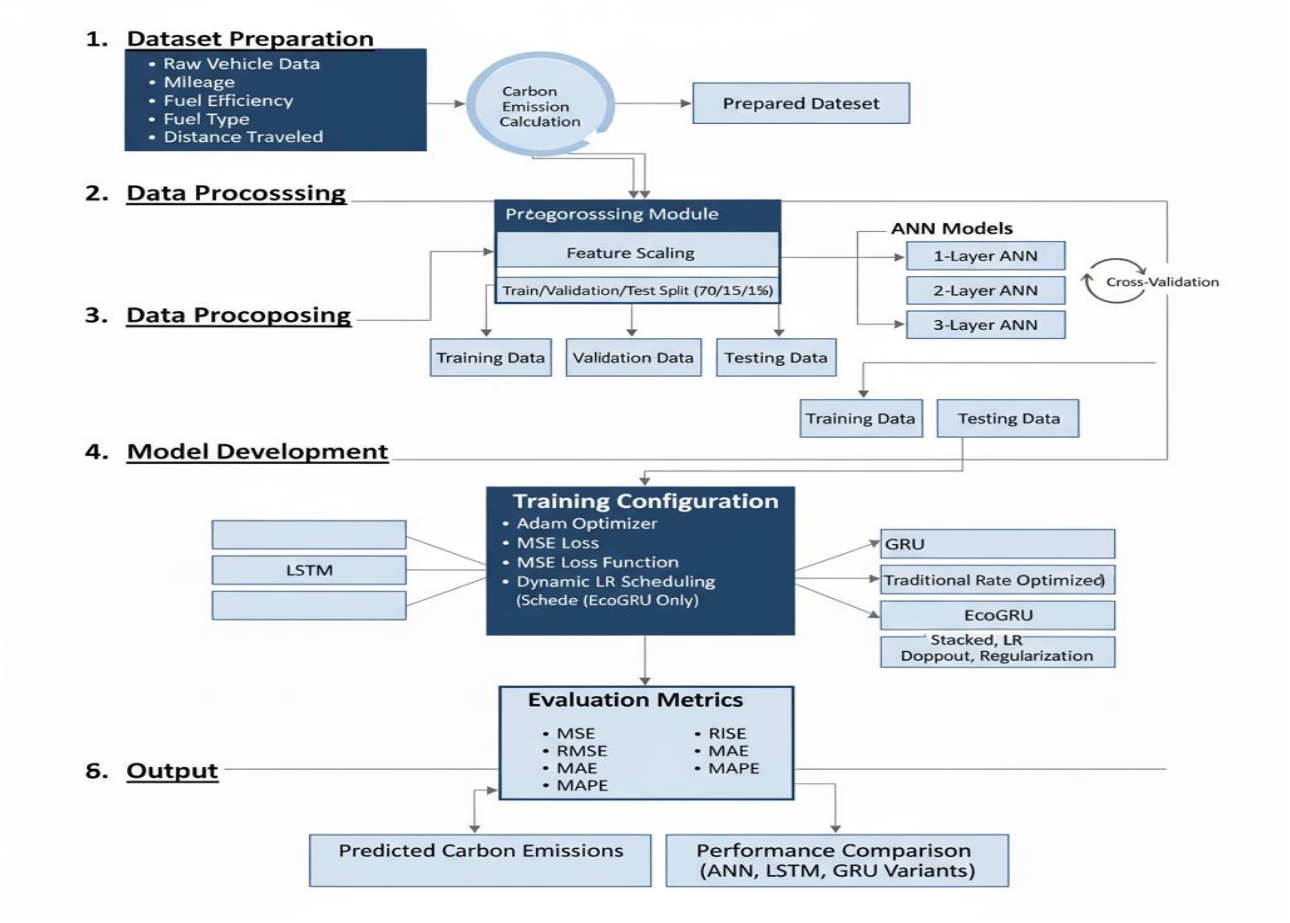

Figure 1: Proposed System Architecture for Vehicular Carbon Emission Prediction

Result and Conclusion:

1. In conclusion, the of the experiments indicate that deep learning models can efficiently predict vehicleed carbon emissions by using the parameters from the real-world datasets. The proposed models (ANN, LSTM, GRU, and the EcoGRU) were trained and tested on multiple evaluation metrics using uniform preprocessing methods.
2. Based on the performance comparison graph, GRU model has best overall performance with lowest MAE and RMSE as well as the highest R2 value in terms of prediction accuracy and reliability. The ANN had relatively larger errors so was less able to model non-linearities in the emission data.

3. The LSTM has a moderate performance and takes the advantage of memory-based learning, but has a larger RMSE than GRU. The proposed EcoGRU achieves a good balance between excellent generalization and low overfitting through adopting stacked layers, dropout regularization and dynamic learning rate scheduling.
4. In general, the results confirm that RNN-based models, especially GRU and EcoGRU, are very competitive for the prediction of carbon emission tasks. With this the final developed system is capable of predicting the emission values with increasing accuracy based on vehicle parameters and thus serve as a trustable platform to evaluate the carbon footprints of individual. The results indicate that the proposed SCEETS have a potentiality to be used in sustainable transportation planning and environmental surveillance. The results also prove that deep learning methods are capable of further improving prediction accuracy, which could lead to scalable system-based carbon emission estimation.

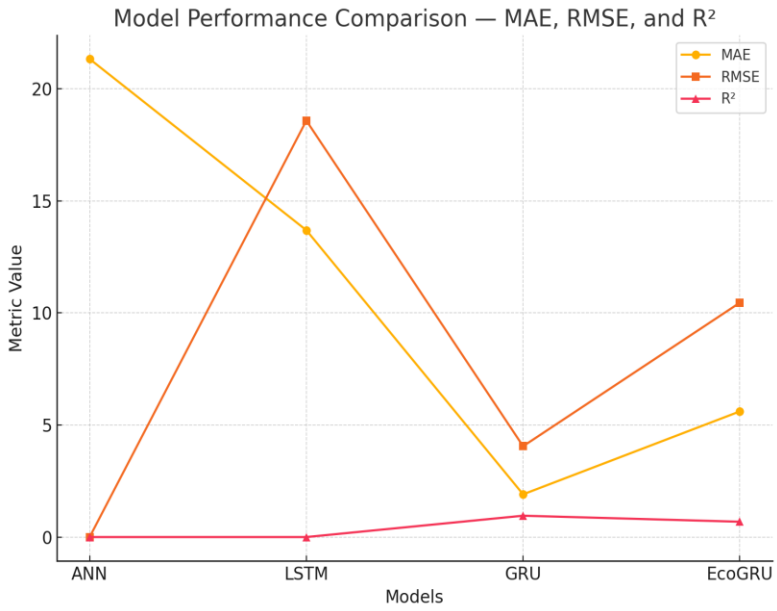

Figure 2: Comparative performance analysis of ANN, LSTM, GRU, and EcoGRU models based on MAE, RMSE, and R^2 metrics.

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Future Scope:

The future scope of this project includes:

1. **Real-Time Data Integration:**
   The system could be adapted to gather real-time vehicle data from IoT sensors or mobile applications, enabling the user to monitor carbon emissions in real time.
2. **Dissemination as a Web or Mobile Application:**
   The suggested model can be implemented as a friendly web or mobile application for users to keep track of their daily carbon footprint and get recommendations on how to lower emissions.
3. **Generalization with Larger and Additional Datasets:**
   In the future, the work can be extended by training models with larger datasets from various regions and different types of vehicles under a variety of environmental conditions to enhance the accuracy and scalability of predictions.
4. **Integration of Sophisticated Hybrid Models:**
   In addition, the system may be generalized by either designing hybrid deep learning models (recurrent convolutional deep belief network) or/and integrating explainable AI methods for further improving the prediction performance as well as the transparency of the decisions.