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Machine Learning for Real-Time Fuel Consumption Prediction and Driving Profile Classification based on ECU Data

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Abstract: *This paper represents a machine learning- based system for real-time fuel consumption prediction and driving profile classification using ECU (Electronic Control Unit) data from vehicles. Key engine parameters such as vehicle speed, engine RPM, throttle position, and mass air flow are used to train predictive models.*
Algorithms used for fuel prediction are XGBoost, SVR, Ridge Regression, Random Forest, and AdaBoost. Similarly, Logistic Regression, Random Forest, and AdaBoost algorithms are used to classify the type of driver behavior along with suggestions into seven categories. The models are evaluated using standard metrics. Results indicate high accuracy in both prediction and classification tasks. This system supports applications in eco-driving systems, fleet management, and driver behavior analysis, promoting fuel efficiency and safer driving habits...

Keywords: ECU Data , Driver Behavior Analysis , XGBoost , Machine Learning

I. INTRODUCTION

Optimization of fuel consumption and driver behavior assessment are important elements of gree n transportation. Taking advantage of in- vehicle real-time Electronic Control Unit (ECU) data, this paper gives an overview of a machine learning-based framework for predicting fuel consumption and driving profile categorization. Advanced regression models and supervised classifiers are utilized to forecast fuel efficiency and classify driving behavior into seven profiles: Eco, Calm, Aggressive, Sporty, Normal, Smooth, and Distracted. The system can be used with applications in eco-driving, fleet management, and driver monitoring.
Keywords :.

II. AIM

The aim of this study is to develop a real-time machine learning-based system for accurately predicting vehicle fuel consumption and classifying driving profiles based on ECU data.

III. OBJECTIVE

- To develop a machine learning-based system for real-time fuel consumption prediction and driving profile classification using ECU data.
- To apply advanced regression models (XGBoost, SVR, Ridge Regression, Random Forest, AdaBoost) for fuel consumption estimation.
- To classify driving behavior into one of seven profiles—Eco, Calm, Aggressive, Sporty, Normal, Smooth, and Distracted—using supervised learning algorithms such as Logistic Regression, Random Forest, and AdaBoost.

IV. LITERATURE REVIEW

Machine learning (ML) methods have demonstrated high potential in enhancing fuel consumption forecast and driver behavior analysis based on vehicular data.

Zhang et al. discussed ML-based methods for fuel consumption model prediction, pointing out that ensemble models like Random Forest and XGBoost can deliver robust predictive accuracy upon training from Electronic Control Unit (ECU) and CAN bus data parameters.

Ezzini and Bengler demonstrated that supervised classifiers could effectively identify different driving styles with telematics data and improve monitoring and optimization capabilities of driver behavior.

Wu et al. explored deep learning approaches for driving style recognition but such methods often require large labeled datasets and high computational resources.

V. METHODOLOGIES

This work follows a machine learning-oriented methodology, including data collection, preprocessing, feature engineering, model creation, and evaluation to forecast fuel consumption and classify driving profiles.

Data Acquisition

Data was retrieved from the vehicle's CAN bus and ECU, including values such as gear position, brake pressure, speed, RPM, throttle position, and fuel rate. Labels for driving profiles (Eco, Aggressive, Calm, Normal, Sporty) and fuel consumption (in L/h) were determined from annotated and real-time data.

Preprocessing and Feature Engineering

Missing values were treated through imputation or deletion. Features were scaled using Standard Scaler, and categorical variables were encoded. Driving behavior classification was performed using time-window segmentation. Additional features such as jerk, acceleration change rate, and throttle- brake ratios were engineered to support model learning.

Model Development

1) Fuel Consumption Prediction:

Implemented using SVR, Random Forest, XGBoost, and Decision Tree regressors.

2) Driving Profile Classification:

Performed using Logistic Regression, Random Forest, SVM, AdaBoost, and Gradient Boosting. Models were assessed based on accuracy, F1-score, and confusion matrix.

Training and Evaluation

The dataset was split into 70% training and 30% testing. A 5-fold cross-validation strategy was used, and hyperparameters were optimized using Grid SearchCV.

Deployment

The final models are lightweight and suitable for real-time deployment through web applications or embedded systems.

VI. RESULTS AND ANALYSIS

The suggested system was validated using real-time ECU data. For fuel consumption prediction, XGBoost achieved the highest performance followed by SVR, Ridge Regression, Random Forest, and AdaBoost.

For classifying driving behavior into seven profiles (Eco, Calm, Aggressive, Sporty, Normal, Smooth, Distracted), Random Forest yielded the highest accuracy followed by Logistic Regression and AdaBoost. High precision and recall across all profiles indicate reliable classification.

These findings confirm the system's effectiveness for real-time fuel efficiency analysis and driver behavior monitoring.

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OUTPUT SCREENS

Fig 1 Index page

Fig 2 Userhome Page

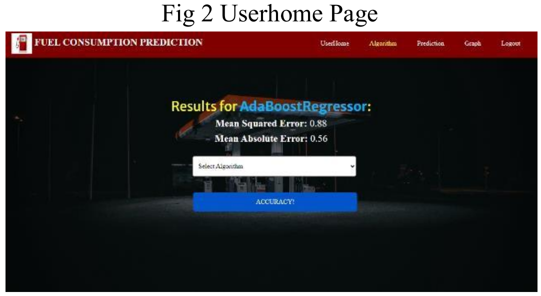

Fig 3 Algorithm Page

VII. CONCLUSION

This paper introduces a machine learning approach for predicting real-time fuel consumption and driver behavior classification through ECU data. The proposed system efficiently integrates regression models and supervised classifiers for fuel efficiency prediction and driver behavior classification into seven profiles: Eco, Calm, Aggressive, Sporty, Normal, Smooth, and Distracted. Results indicate high accuracy and reliability, validating the potential of the system for use in eco-driving, driver monitoring, and smart fleet management. In future research, the system can be extended with more varied driving environments and larger datasets. Real-world deployment with edge computing or IoT integration could also enable more robust real-time analysis and feedback.

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