Trip Based Modeling of Fuel Consumption in Modern Fleet Vehicles

Abstract

Ability to model and predict the fuel consumption is vital in enhancing fuel economy of vehicles and preventing fraudulent activities in fleet management. Fuel consumption of a vehicle depends on several internal factors such as distance, load, vehicle characteristics, and driver behavior, as well as external factors such as road conditions, traffic, and weather. However, not all these factors may be measured or available for the fuel consumption analysis. We consider a case where only a subset of the aforementioned factors is available as a multi-variate time series from a long distance, public bus. Hence, the challenge is to model and/or predict the fuel consumption only with the available data, while still indirectly capturing as much as influences from other internal and external factors. Machine Learning (ML) is suitable in such analysis, as the model can be developed by learning the patterns in data. In this paper, we compare the predictive ability of three ML techniques in predicting the fuel consumption of the bus, given all available parameters as a time series. Based on the analysis, it can be concluded that the random forest technique produces a more accurate prediction compared to both the gradient boosting and neural networks.

Introduction

These models describe the dynamics of the components of the vehicle at each time step using detailed mathematical equations . Machine learning models, which are data-driven and represent an abstract mapping from an input space consisting of a selected set of predictors to an output space that represents the target output, in this case average fuel consumption . Statistical models, which are also data-driven and establish a mapping between the probability distribution of a selected set of predictors and the target outcome.

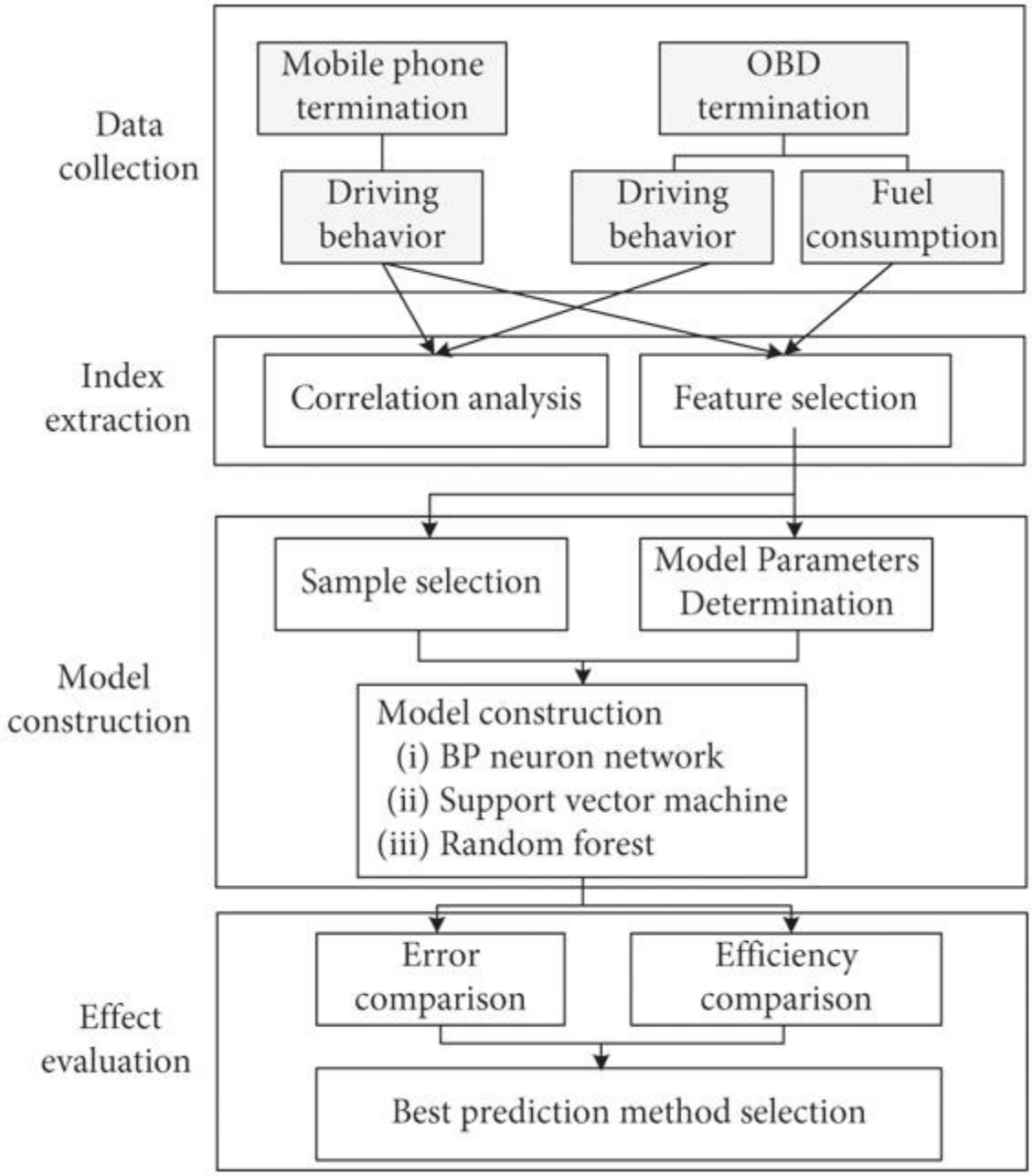
Relying on accurate models of all of the vehicles in a fleet, a fleet This research was supported in part by Allison Transmission, Inc. manager can optimize the route planning for all of the vehicles based on each unique vehicle predicted fuel consumption thereby ensuring the route assignments are aligned to minimize overall fleet fuel consumption. These types of fleets exist in various sectors including, road transportation of goods , public transportation , construction trucks

and refuse trucks. For each fleet, the methodology must apply and adapt to many different vehicle technologies (including future ones) and configurations without detailed knowledge of the vehicles specific physical characteristics and measurement.

Methods

Analysis Framework

Since mobile phones cannot obtain the data of vehicles' fuel consumption directly, the driving behavior data collected from mobile phones and the fuel consumption collected from OBD were matched, and the fuel consumption prediction model was built. In the process of model construction, the data collected from mobile phones and OBD were both applied. After the model was built, larger-scale traffic fuel consumption was able to be predicted using only the driving behavior data collected from the mobile phones. The framework of model construction is shown in Figure 1. The steps of fuel consumption prediction are as follows:(1)Data collection: natural driving behavior data of multiple drivers were collected based on GPS, linear accelerometer, gyroscope, and other sensors of mobile phones. At the same time, the real-time vehicle fuel consumption data were collected by the OBD terminal installed in the vehicle simultaneously.(2)Index extraction: the data of mobile phones and OBD terminals were combined based on time. By comparing the consistency and difference of driving behavior data of the two terminals, the indexes for predicting vehicle fuel consumption based on mobile phone data were extracted.(3)Model construction: the training set and test set were selected randomly, and the fuel consumption prediction models were built using a back propagation (BP) neural network, a support vector machine, and a random forest.(4)Effect evaluation: by building the fuel consumption prediction models several times and comparing the accuracy and efficiency of the three prediction models using different methods, the best method to predict vehicle fuel consumption based on mobile terminals is proposed.


Data collection
Mobile phone termination
OBD termination
Driving behavior
Driving behavior
Fuel consumption
Index extraction
Correlation analysis
Feature selection
Model construction
Sample selection
Model Parameters Determination
Model construction
(i) BP neuron network
(ii) Support vector machine
(iii) Random forest
Effect evaluation
Error comparison
Efficiency comparison
Best prediction method selection

Hardware Requirements

- 8GB RAM
- Intel Core i3
- Laptop/Desktop
- Windows/MAC/Linux OS.

Software Requirements

- Python
- numpy
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- Pandas
- Seaborn
- Matplotlib.pyplot

Conclusion

In this study, driving behavior data and fuel consumption data of taxi drivers collected from OBD and mobile phone terminals, respectively, were matched. The correlation between driving behavior and fuel consumption was analyzed, and relevant driving behavior indicators affecting fuel consumption were extracted through the filter-based feature selection method. Using the seven selected driving behavior indicators (namely, average speed, ASEI, average acceleration, average deceleration, acceleration time percentage, deceleration time percentage, and cruising time percentage), three fuel consumption prediction models based on a BP neural network, SVR, and a random forest were constructed.

The results of model error and the run time comparison analysis show that the three models could predict fuel consumption accurately, and the random forest model had the highest accuracy and efficiency, with an RMSE of 0.783 L/100 km,

mean absolute percentage error (K) of 6.9%, and model running time of 0.14 s. This finding is consistent with the research of Wickramanayake and Bandara [15], which also shows that random forest models are most effective in predicting fuel consumption based on driving behavior data. The research object of Wickramanayake and Bandara is the fuel consumption prediction of the bus, and this study focuses on the fuel consumption of the taxicabs. At the same time, the driving behavior data of this study are collected from mobile phones with higher flexibility and complexity rather than a fixed GPS device. This method could predict vehicle fuel consumption with high accuracy and efficiency based on cell phone data and provide strong support for traffic management departments to monitor the ecological levels of driving behavior of taxi drivers.