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A MACHINE LEARNING MODEL FOR AVERAGE FUEL CONSUMPTION IN HEAVY VEHICLES

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ABSTRACT

We used vehicle travel distance rather than the traditional time period when developing individualized machine learning models for fuel consumption. This approach is used in conjunction with seven predictors derived from vehicle speed and road grade to produce a highly predictive neural network model for average fuel consumption in heavy vehicles. The proposed model can easily be developed and deployed for each individual vehicle in a fleet in order to optimize fuel consumption over the entire fleet. The predictors of the model are aggregated over fixed window sizes of distance travelled. Different window sizes are evaluated and the results show that a 1 km window is able to predict fuel consumption with a 0.91 coefficient of determination and mean absolute peak-to-peak percent error less than 4% for routes that include both city and highway duty cycle segments.

INTRODUCTION

FUEL consumption models for vehicles are of interest to manufacturers, regulators, and consumers. They are needed across all the phases of the vehicle life-cycle. We focus on modeling average fuel consumption for heavy vehicles during the operation and maintenance phase. In general, techniques used to develop models for fuel consumption fall under three main categories:Physics-based models:-which are derived from an in-depth understanding of the physical system. These models describe the dynamics of the components of the vehicleMachine 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.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.a model that can be easily developed for individual heavy vehicles in a large fleet is proposed.

Relying on accurate models of all of the vehicles in a fleet, a fleet 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 measurements.

SYSTEM ANALYSIS

EXISTING SYSTEM:-

Model that can be easily developed for individual heavy vehicles in a large fleet is proposed. Relying on accurate models of all of the vehicles in a fleet, a fleet 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.
This approach is used in conjunction with seven predictors derived from vehicle speed and road grade to produce a highly predictive neural network model for average fuel consumption in heavy vehicles.
Different window sizes are evaluated and the results show that a 1 km window is able to predict fuel consumption with a 0.91 coefficient of determination and mean absolute peak-to-peak percent error less than 4% for routes that include both city and highway duty cycle segments.

DISADVANTAGES:

Physics-based models, which are derived from an in-depth understanding of the physical system. These models describe the dynamics of the components of the vehicle each time step using detailed mathematical equations.
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.

PROPOSED SYSTEM:-

As mentioned above Artificial Neural Networks (ANN) are often used to develop digital models for complex systems. The models proposed highlight some of the difficulties faced by machine learning models when the input and output have different domains. In this study, the input is aggregated in the time domain over 10 minutes intervals and the output is fuel consumption over the distance traveled during the same time period. The complex system is represented by a transfer function $F(p) = o$, where $F(\cdot)$ represents the system, p refers to the input predictors and o is the response of the system or the output. The ANNs used in this paper are Feed Forward Neural Networks (FNN).
Training is an iterative process and can be performed using multiple approaches including particle swarm optimization and back propagation. Other approaches will be considered in future work in order to evaluation their ability to improve the

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model's predictive accuracy. Each iteration in the training selects a pair of (input, output) features from Ftr at random and updates the weights in the network. This is done by calculating the error between the actual output value and the value predicted by the model

ADVANTAGES:

- Data is collected at a rate that is proportional to its impact on the outcome. When the input space is sampled with respect to time, the amount of data collected from a vehicle at a stop is the same as the amount of data collected when the vehicle is moving.

- The predictors in the model are able to capture the impact of both the duty cycle and the environment on the average fuel consumption of the vehicle (e.g., the number of stops in an urban traffic over a given distance).

- Data from raw sensors can be aggregated on-board into few predictors with lower storage and transmission bandwidth requirements. Given the increase in computational capabilities of new vehicles, data summarization is best performed on-board near the source of the data.

IMPLEMENTATION

MODULES:-

Upload Heavy Vehicles Fuel Dataset:-

Using this module we can upload train dataset to application. Dataset contains comma separated values.

Read Dataset & Generate Model:-

Using this module we will parse comma separated dataset and then generate train and test model for ANN from that dataset values. Dataset will be divided into 80% and 20% format, 80% will be used to train ANN model and 20% will be used to test ANN model.

Run ANN Algorithm:

Using this model we can create ANN object and then feed train and test data to build ANN model.

Predict Average Fuel Consumption:

Using this module we will upload new test data and then ANN will apply train model on that test data to predict average fuel consumption for that test records.

Fuel Consumption Graph:

Using this module we will plot fuel consumption graph for each test record.

Results

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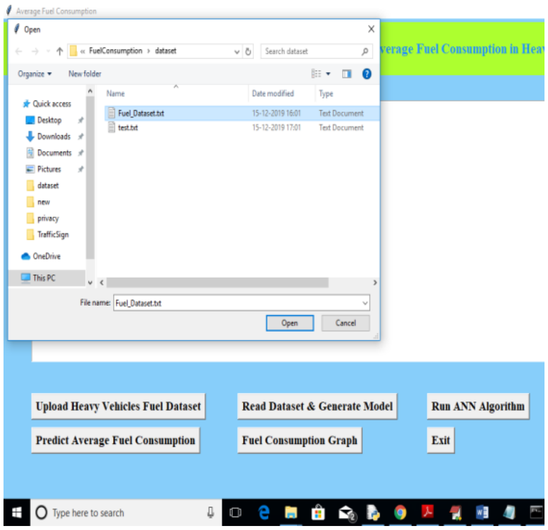
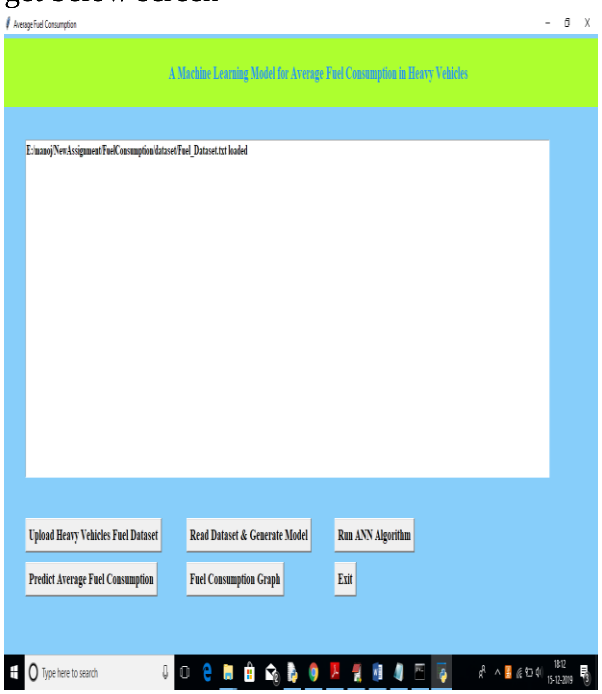
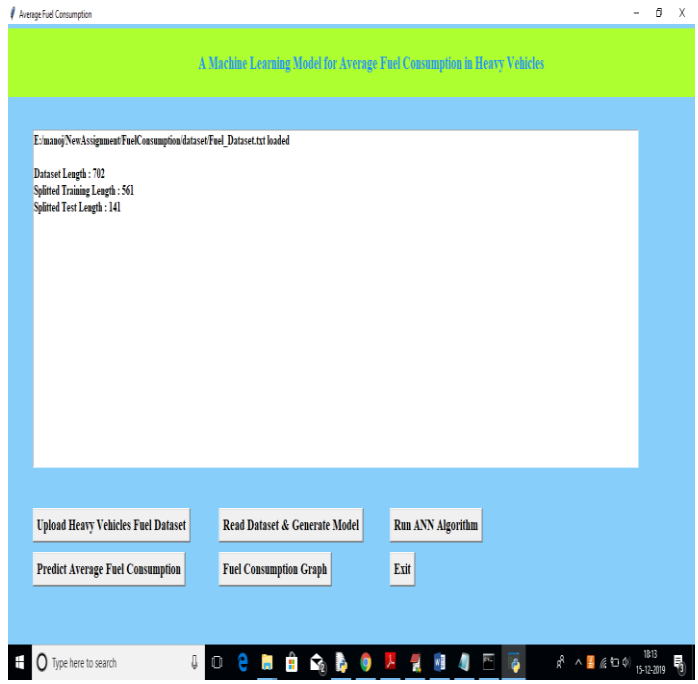
In above screen click on 'Upload Heavy Vehicles Fuel Dataset' button to upload train dataset



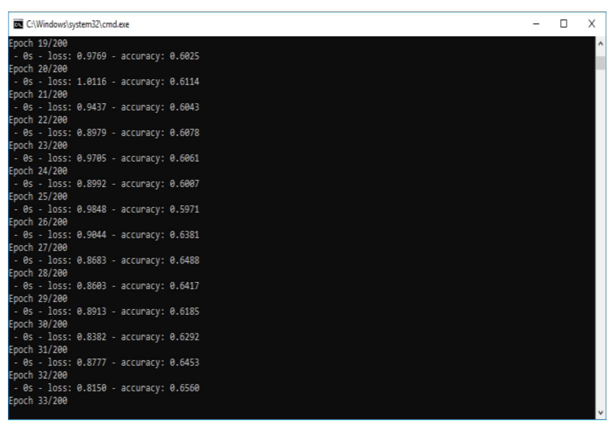
In above screen uploading 'Fuel_Dataset.txt' which can be used to train model. After uploading dataset will get below screen



Now in above screen click on 'Read Dataset & Generate Model' button to read uploaded dataset and to generate train and test data



In above screen we can see total number of records in dataset, number of records used for training and number for records used for testing. Now click on 'Run ANN Algorithm' button to input train and test data to ANN to build ANN model.



In above black console we can see all ANN processing details, After building model will get below screen

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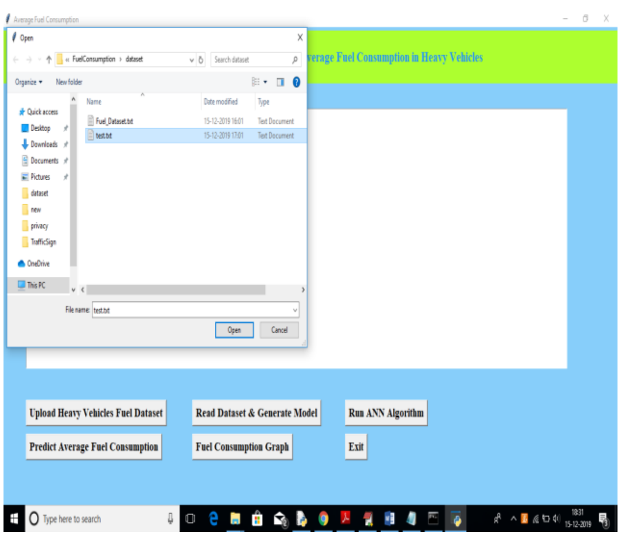
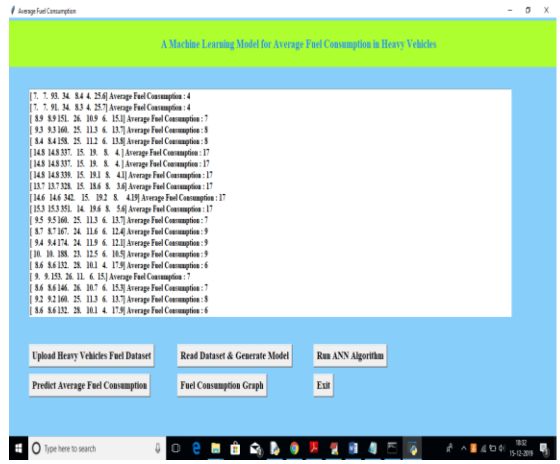
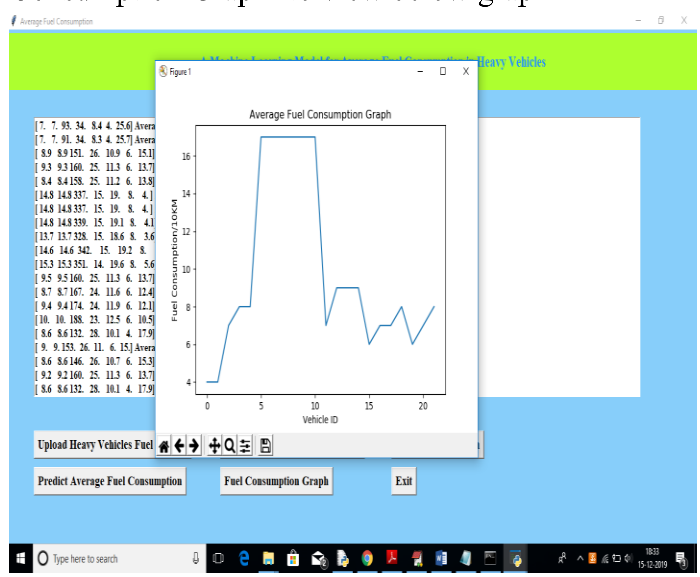
In above screen we got ANN prediction accuracy upto 86%. Now click on 'Predict Average Fuel Consumption' button to upload test data and to predict consumption for test data



After uploading test data will get fuel consumption prediction result in below screen



In above screen we got average fuel consumption for each test record per 100 kilo meter. Now click on 'Fuel Consumption Graph' to view below graph



In above graph x-axis represents test record number as vehicle id and y-axis represents fuel consumption for that record.

CONCLUSION

Machine learning model that can be conveniently developed for each heavy vehicle in a fleet.

The model relies on seven predictors: number of stops, stop time, average moving speed, characteristic acceleration, aerodynamic speed squared, change in

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kinetic energy and change in potential energy.

The last two predictors are introduced in this paper to help capture the average dynamic behavior of the vehicle. All of the predictors of the model are derived from vehicle speed and road grade.

These variables are readily available from telematics devices that are becoming an integral part of connected vehicles. Moreover, the predictors can be easily computed on-board from these two variables.

FUTURE SCOPE:

- Future work also includes investigating the minimum distance required for training each model and analyzing how often does a model need to be synchronized with the physical system in operation by using online training in order to maintain the prediction accuracy of the model.
- Predict average fuel consumption in heavy vehicles using Machine Learning Algorithm such as ANN (Artificial Neural Networks). To predict fuel consumption author has extracted 7 predictor features from heavy vehicle dataset such as
- Num_stops, time_stopped, average_moving_speed, characteristic_acceleration, aerodynamic_speed_squared, change_ in_kinetic_energy, change_in_potential_energy,class.

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