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PREDICTIVE MODELING OF AVERAGE FUEL CONSUMPTION IN HEAVY VEHICLES USING MACHINE LEARNING

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ABSTRACT

Artificial Neural Networks are a type of machine learning algorithm inspired by the human brain's neural structure. They are widely used for various prediction tasks due to their ability to learn complex patterns and relationships from data. In this project, ANN model is proposed to estimate the average fuel consumption of heavy vehicles. The dataset used in the study is likely referred to as the "Heavy Vehicle Fuel Dataset," and it contains relevant information about different heavy vehicles, such as their characteristics, driving conditions, and corresponding fuel consumption measurements. This dataset is likely carefully curated to ensure its accuracy and representativeness for the specific task of predicting fuel consumption in heavy vehicles.

Keywords: Fuel consumption, ANN, machine learning.

1. INTRODUCTION

Problem statement

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. In this paper, 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 vehicle at each time step using detailed mathematical equations [1], [2]. • 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 [3], [4]. • 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 [5], [6].

Motivation

Trade-offs among the above techniques are primarily with respect to cost and accuracy as per the requirements of the intended application.

In this paper, 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 [7], public transportation [3], construction trucks [8] and refuse trucks [9]. 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. These requirements make machine learning the technique of choice when taking into consideration the desired accuracy versus the cost of the development and adaptation of an individualized model for each vehicle in the fleet.

Objective

Existing 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.

2. PROPOSED SYSTEM

As mentioned above Artificial Neural Networks (ANN) are often used to develop digital models for complex systems.

The models proposed in [15] 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 [20] and back propagation. Other approaches will be considered in future work in order to evaluation their ability to improve the 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 of proposed system:

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.

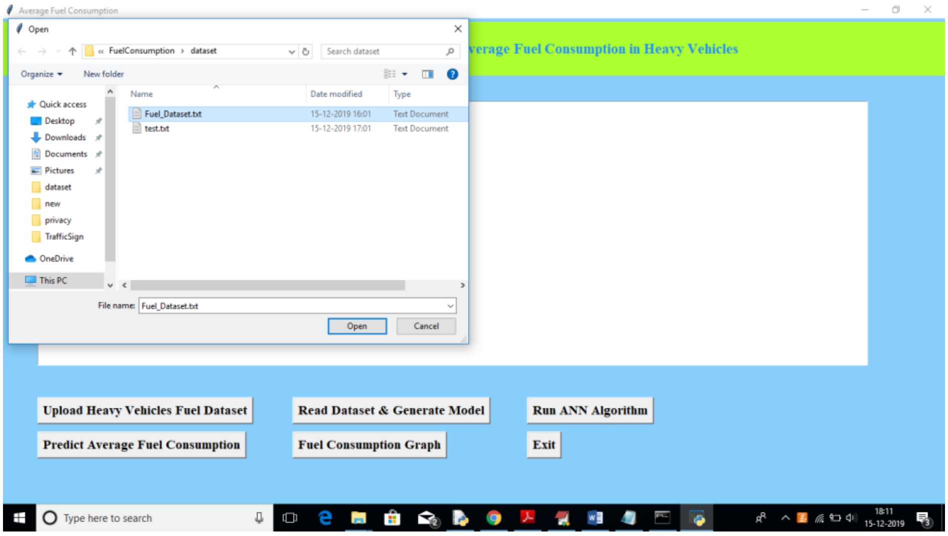
The predictors in the model are able to capture the impact of both the duty cycle and the environment on the average fuel consumption of the vehicle (e.g., the number of stops in an urban traffic over a given distance).

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.

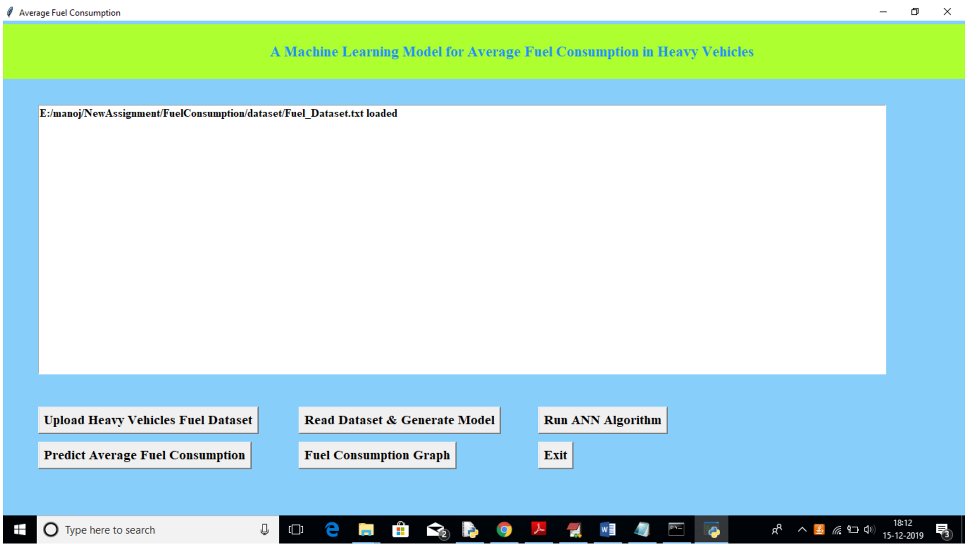
3. RESULTS

To run this project double click on 'run.bat' file to get below screen.

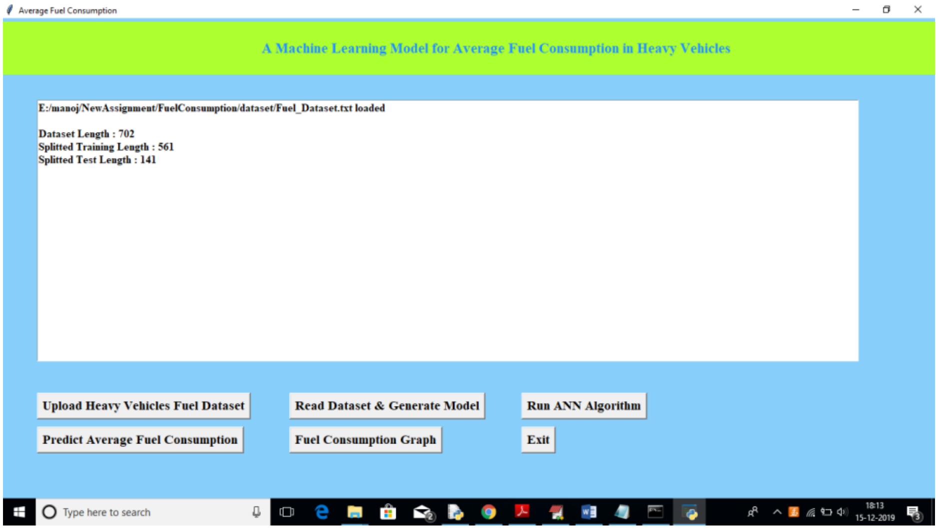
In above screen click on 'Upload Heavy Vehicles Fuel Dataset' button to upload train dataset



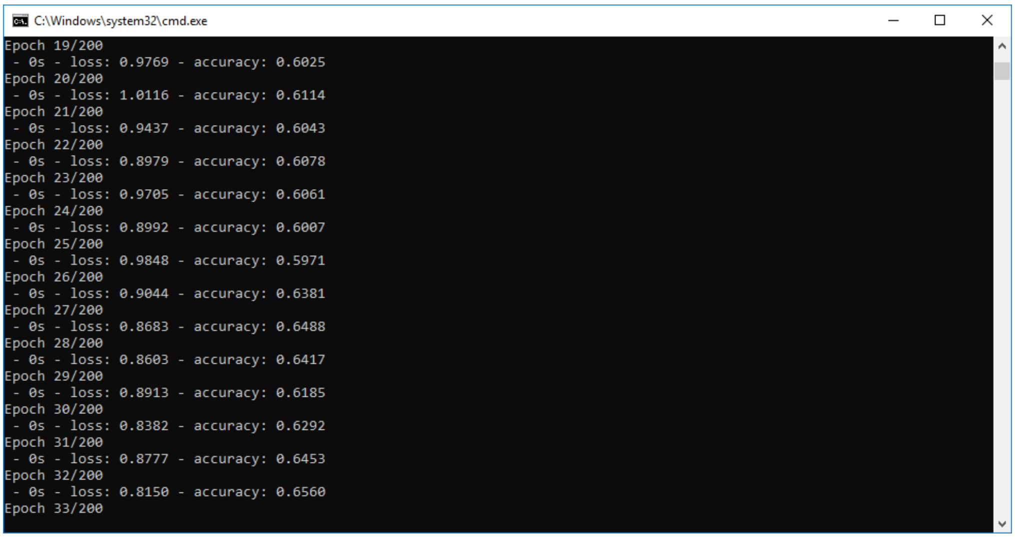
In above screen uploading 'Fuel_Dataset.txt' which can be used to train model. After uploading dataset will get below screen



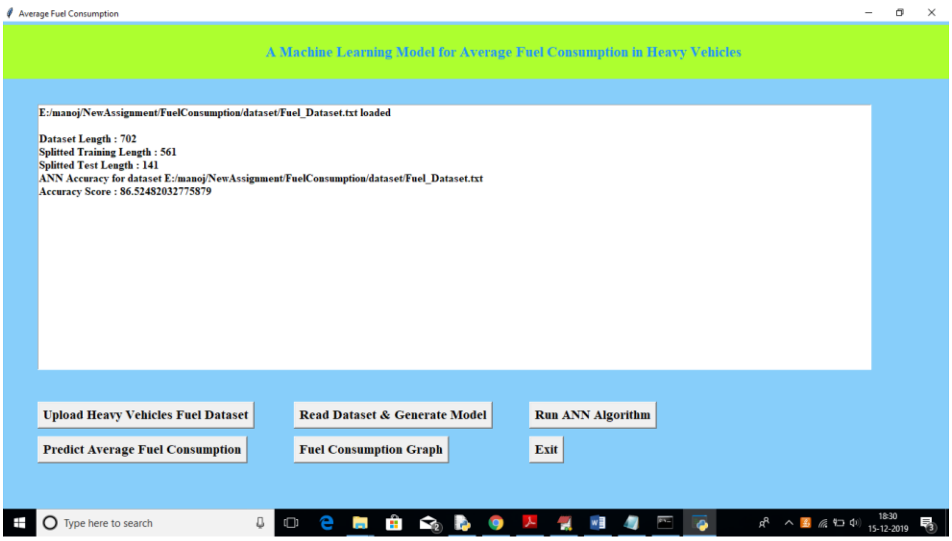
Now in above screen click on 'Read Dataset & Generate Model' button to read uploaded dataset and to generate train and test data



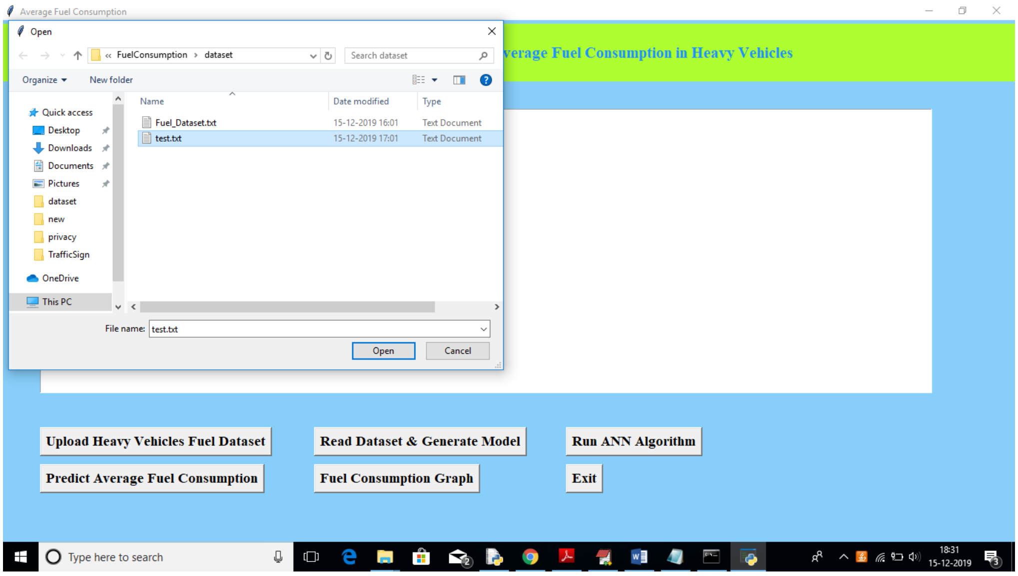
In above screen we can see total number of records in dataset, number of records used for training and number for records used for testing. Now click on 'Run ANN Algorithm' button to input train and test data to ANN to build ANN model.



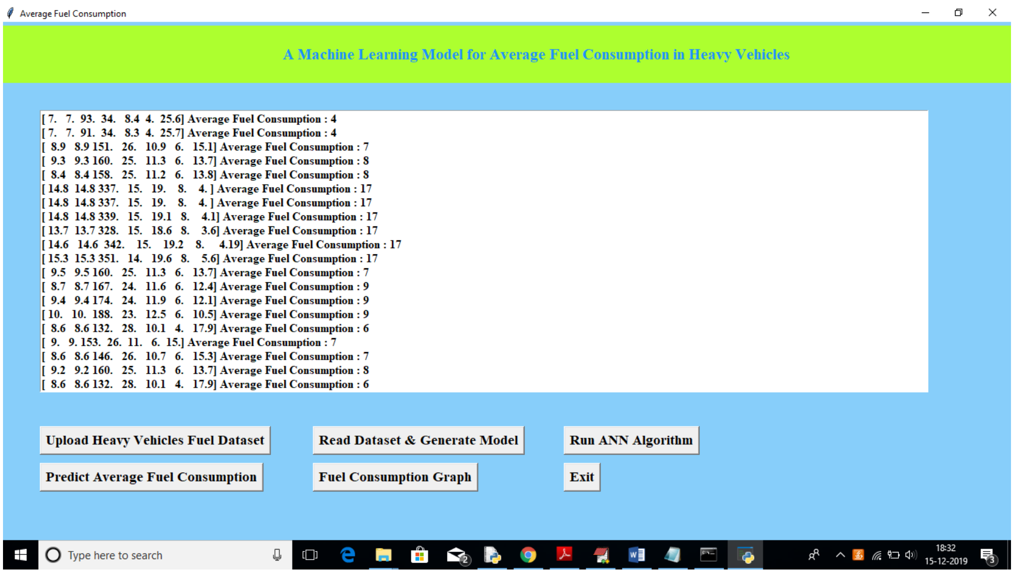
In above black console we can see all ANN processing details, After building model will get below screen



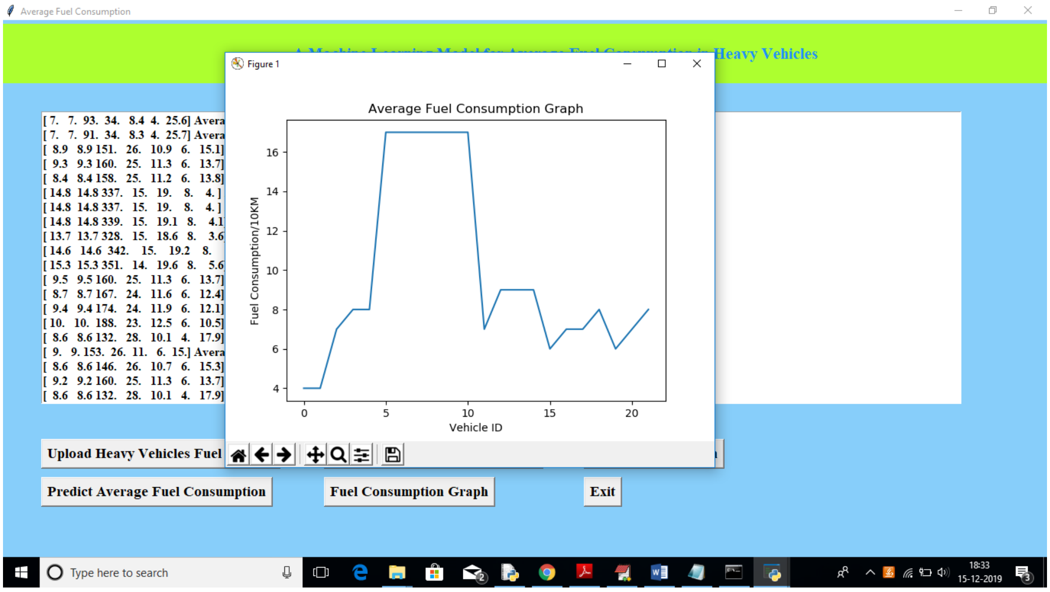
In above screen we got ANN prediction accuracy upto 86%. Now click on 'Predict Average Fuel Consumption' button to upload test data and to predict consumption for test data



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.

4. CONCLUSION & FUTURE WORK

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 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 Work

In this paper author is describing concept to 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.

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