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Statistical Evaluation and Prediction of Fuel Utilization in Vehicles

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Abstract: ***The transportation sector is a big energy consumer and one of the largest greenhouse gas emissions contributors. Governments around the world are taking steps to address the energy and GHG emissions problems caused by transportation. This paper will help in predicting the average energy consumption in vehicles using a Machine learning Model considering a few internal and external predictors. In this paper, three Machine Learning techniques have been investigated, three models developed and their performances compared. The model which gives the higest accuracy will be choosen to predict the energy consumption. This paper will be of interest to manufacturers, consumers and regulators.***

Keywords: Artificial neural Nets, Support Vector Machine, Random Forest, Fuel Consumption, Prediction, Machine Learning Model, Predictors

I. INTRODUCTION

Energy Consumption or Fuel Consumption is an occurance in vehicles as they burn fuel to get the energy to run.It is measured per unit distance travelled. World consumes about 88 million barrels of fuel each day. Due to the possibility of reduced availability of fossil fuels in the succeding years and the increasing cost of fuel price, minimizing fuel consumption is a major concern as far as sustainable engineering is concerned. Tranportation sector is a big contributor of the emission of exhaust gases into the atmosphere which cause immediate and long-term effects on the environment. They emit a wide range of gases and solid matter, causing global warming, harming the environment and human health. Whereas, fuel-efficient cars have a reduced impact. Knowing the factors that are majorly contributing to excess consumption, fuel economy can be maximized by removing all the unneeded items.The prediction model could also be used for anomaly detection and identify vehicles with irregular fuel consumption.

In this paper, three Machine Learning techniques such as Support Vector Machine, Random Forest and Artificial Neural Networks are employed to predict the average fuel consumption.Machine Learning (ML) is suitable in such analysis, as the model can be developed by learning the patterns in data.The model is trained on the prepared dataset of predictors. The Machine Learning algorithm which gives the highest precision will be further used for prediction on the test dataset.

II. LITERATURE REVIEW

Under literature review,the work contributed towards predicting average fuel consumption is mentioned.Physics-based, machine learning, and statistical models have all been used to model average fuel consumption.The EPA and the European Commission developed physics-based models,full vehicle simulation models for vehicles.These models were capable of predicting average fuel consumption with an accuracy of (+ or -) 3% compared to the real measurements obtained from the flowmeter.Rizzotto et al. (1995) presented a data-based fuzzy logic fuel consumption model. The results of fuel consumption measurements in that research were correlated to a set of independent variables which represent the vehicle average speed, number of passengers on board, and the actual elevation of the road.They repord that Fuzzy logic is more efficent than traditional mathemtical methods.Ahn et al in (2002) proposed statistical regression models that predict vehicle fuel consumption and emission rates with key input variables of instantaneous vehicle speed and acceleration measurements.

The statistical based method such as the SAE J1321 standard is used to estimate fuel consumption,This standard compares similar vehicles following the same route under similar operating conditions using real time data.A statistical based method is only good for the analysis purpose. If data is collected using faulty or biased procedure then it results will be misleading.Wang et al. examined the influence of driving patterns on fuel consumption using a portable emissions measurement system It concluded that vehicle fuel consumption is optimal at speeds between 50 and 70 km/and that fuel consumption increases significantly during acceleration. These results indicate that both the speed limit of the road and driver behavior have large impact on fuel consumption.Various other machine learning models were also used for prediction, since a very few predictors were considered they did not yield accurate results.

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III. PROPOSED SYSTEM

The proposed model can easily be developed predictand deployed for each individual vehicle in a fleet in order to optimize fuel consumption over the entire fleet.In this a comparison is done between the three machine learning models such as Support Vector Machine (SVM),Random Forest (RF) and Artificial Neural Networks(ANN) to predict the average fuel consumption of vehicles. Based on the dataset given,accuracy of each of the machine learning model is obtained and a comparison graph of the three is also shown.The best model will be further used to predict the fuel consumption and plot a fuel consumption graph.Proposed approach differs from that used in previous models because the input space of the predictors is quantized with respect to a fixed distance as opposed to a fixed time period. In the proposed model, all the predictors are aggregated with respect to a fixed window that represents the distance traveled by the vehicle thereby providing a better mapping from the input space to the output space of the model.
The propsed model has several benefits such as

1) Data is collected at a rate that is propotional to its impact on the outcome..When the input space is sampled with respect to time the amount of data collected from the vehicle at a stop is same as the amount of data collected when the vehicle is moving.
2) Accuracy is high compared to existing system
3) Non linear models are easy to use and understaning.

IV. APPROACH

In this paper,the following approach is followed in a step by step procedure in order to predict the average fuel consumption in vehicle

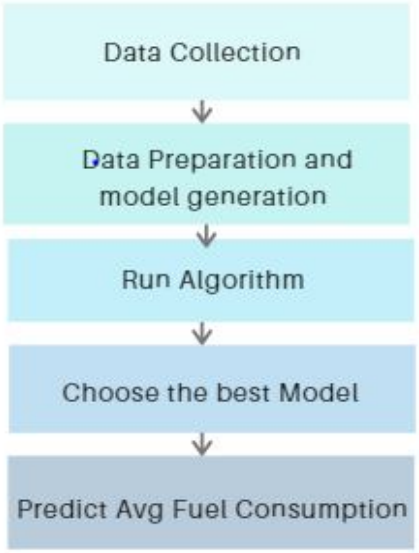

Fig. 1 Approach

A. Data Collection

A dataset is a collection of data. In other words, a data set corresponds to the contents of a single database table, or a single statistical data matrix, where every column of the table represents a particular variable.. In Machine Learning projects, we need a training data set. In this paper,7 predictors are considered which include number of stops, stoptime, average moving speed, characteristic acceleration, aero-dynamic speed squared, change in kinetic energy and change in potential energy.The dataset is stored in the .csv file format.

B. Data Preperation and Generating a Model

Preperation is the stage at which raw data is cleaned up.It deals with duplicates and missing values in the data and organises it for the following stage of data processing. Processing is done using machine learning_algorithms, though the process itself may vary slightly depending on the source of data being processed. In this module we will parse comma separated dataset and then generate train and test model for algorithm from that dataset values. Dataset will be divided into 80% and 20% format,80% will be used to tran th model and 20% will be used to test the model.

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C. Run Algorithm

There are many Machine Learning Techniques which can be used for the prediction purpose. In this paper, three algorithms Support Vector Machine, Random Forest and Artificial Neural Networks are being considered. The features and the limitations of the respective algorithms have been listed in table 1.

TABLE I. Models for Prediction

Algorithm	Feature	Limitation
SVM	It uses a mathematical function, often called a kernel function which matches the new data to the best example from the training data in order to predict the unknown test label	It is not suitable for large data sets. SVM does not perform very well, when the data set has more noise i.e. target classes are overlapping.
RF	It creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting.	The prediction process using random forests is complex and very time-consuming in comparison with other algorithms.
ANN	It processes the records one at a time and learns by comparing their prediction of the record with the known actual record. The errors from the initial prediction are then propagated back through the system and used to modify the network's algorithm for the second iteration.	It is time consuming and requires lot of data especially for arcitecture with many layers

D. Choose the Best Model

In this module, all the three Machine Learning models are applied on the train dataset and their respective accuracy is obtained. The Histogram graph below represents the comparison of all the three.

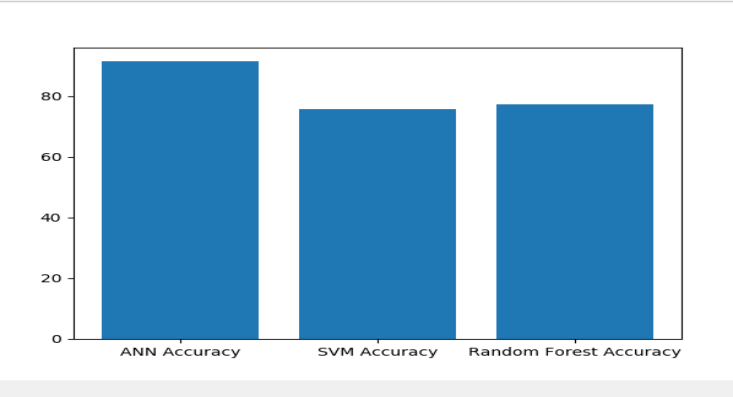

Fig. 2 Comparison Graph

E. Prediction of Fuel Consumption

Prediction refers to the output of an algorithm after it has been trained on a dataset and applied to new data when forecasting the likelihood of a particular outcome. The algorithm will generate probable values for an unknown variable for each record in the new data. Machine learning model predictions make highly accurate guesses as to the likely outcomes of the data.The algorithm with highest precision will be applied on that test data to predict average fuel consumption for that test records.As shown in the Figure 2,Artificial Neural Nets has the highest precision which will be applied on the test dataset for prediction of average fuel consumption.

V. RESULTS

After all the three algorithms are applied on the training set and their performance is obtained,the Machine Learning Algorithm with the highest precision is choosen to develop a model. Once the model is developed, it is then applied on the test dataset to predict the fuel consumption of each test record.

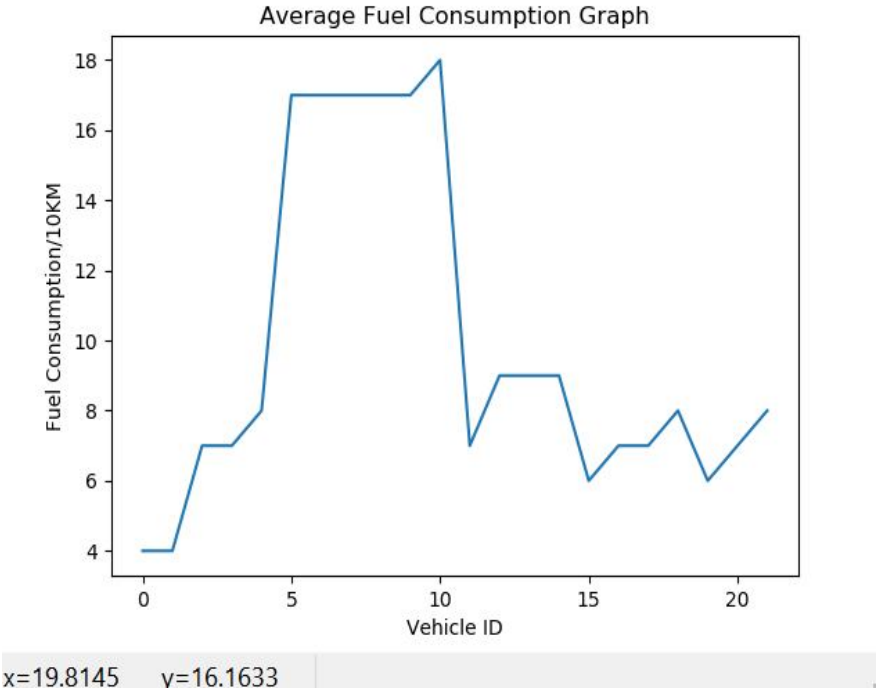

Fig. 3 Fuel Consumption Graph

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

VI. CONCLUSION

The presented work is used to predict the average fuel consumption in vehicles. By knowing what factors are largely contributing to fuel consumption in vehicles, we can keep in mind these factors while manufacturing the particular vehicles. Both external and internal factors are being considered while predicting which gives better results with high precision. A comparison of three algorithms is also done on the trained data before applying on the test records for accurate prediction. A graphical representation is also provided for better understanding.This could be an important finding for the development of maintenance strategies, helping road agencies in reducing costs and greenhouse gas emissions from the road transport sector.

A. Future Scope:

1) Further, there is a scope of expanding the model to others vehicles which posess different characteristics such as varying in mass and aging.Validation of the results for a wider range of vehicles and including more variables, such as the effect of the air temperature, wind speed, driver behavior, etc. can improve the applicability of the study.

2) Selecting an adequate window size should take into consideration the cost of the model in terms of data collection and on-board computation.

3) Algorithms with better performace can be used to train the model.

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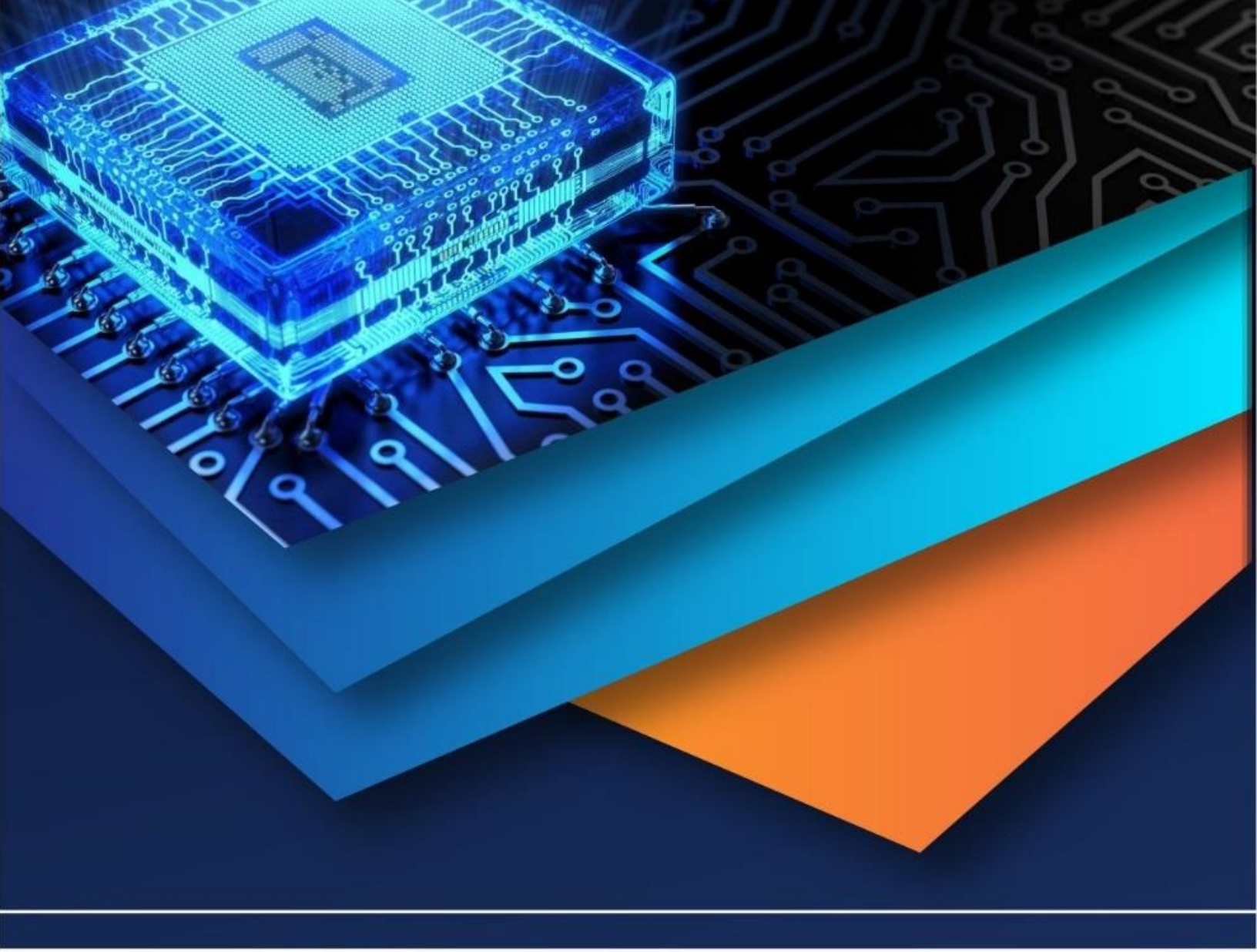

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