A PROJECT REPORT

"Average Fuel Consumption in Heavy Vehicles Using Machine Learning"

A dissertation submitted in partial fulfillment for the requirements for the requirements for the award of the Degree of

MASTER OF COMPUTER APPLICATIONS

Submitted by

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SANKETIKA VIDHYA PARISHAD ENGINEERING COLLEGE

(Approved by AICTE and Affiliated to ANDHRA UNIVERSITY)

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DEPARTMENT OF MASTER OF COMPUTER APPLICATIONS

CERTIFICATE

This is to certify that the Main Project entitled “**Average Fuel Consumption in Heavy Vehicles Using Machine Learning** ” is a bonafied work carried out by **IJJI SAIKIRAN in partial** fulfillment for the award of degree **"MASTER OF COMPUTER APPLICATIONS"** From **Andhra University, Visakhapatnam**

During the year 2022-2023. This work was not submitted earlier at any other University or Institute for the award of any degree

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EXTERNAL EXAMINER

DECLARATION

This is to certify that the project titled " **Average Fuel Consumption in Heavy Vehicles Using Machine Learning** " is a bonafide work done by me, in partial fulfillment of the requirements for the award of the degree MASTER OF COMPUTER APPLICATIONS (MCA) and submitted to the department of Master Of Computer Applications, Sanketika Vidhya Parishad Engineering College, Approved by AICTE, Affiliated to ANDHRA UNIVERSITY. Visakhapatnam, Andhra Pradesh.

I also declare that this project is a result of my own effort and that has not been copied from anyone and I have taken only citations from the sources. Which are mentioned in the references. This work was not submitted earlier at any other University or Institute for the award of any degree.

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PROJECT CONTENTS

INDEX

Average Fuel Consumption in Heavy Vehicles Using Machine Learning

ABSTRACT

In this paper 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. The suggested **ANN-based model** can reliably anticipate the average fuel consumption of heavy trucks, allowing fleet operators to optimize their fuel usage and minimize expenses. This project's findings may also be beneficial to policymakers in developing laws and incentives to increase fuel economy in the transportation industry.

Keywords : Fuel consumption, machine learning, neural network, vehicle travel distance, road grade, fleet optimization, ANN, image classifier, neural network architecture

CHAPTER-1
INTRODUCTION

1.INTRODUCTION

1.1 Project purpose

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 modelling 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

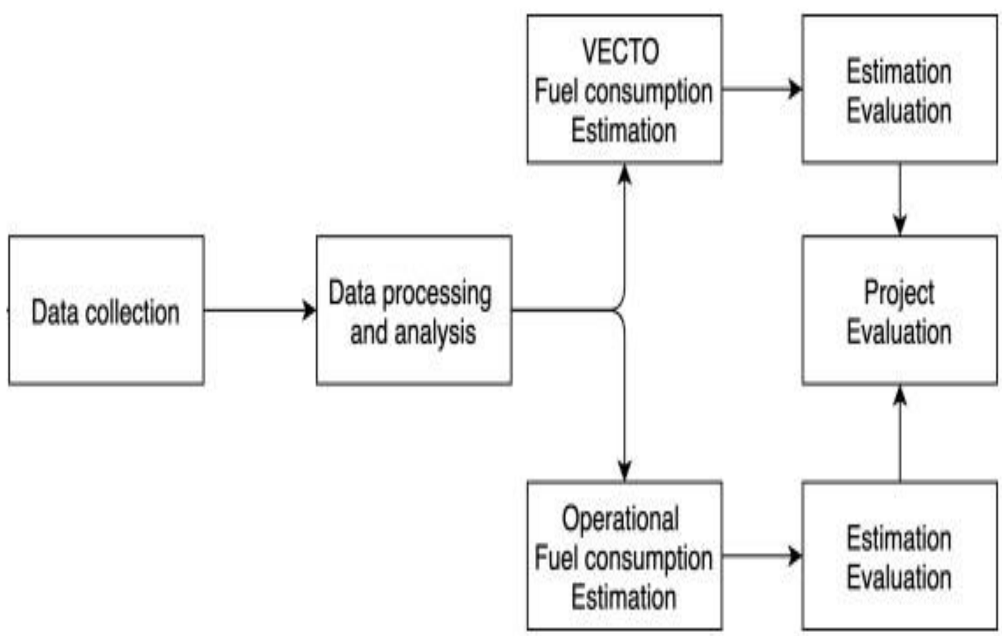
Machine learning models:- which are data-driven and represent an abstract mapping from an input space consisting of a selected set of predictors to an output space that represents the target output.

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.

Fuel utilization models for vehicles are of interest to producers, controllers, and customers. They are required across every one of the periods of the vehicle lifecycle. In this paper, we center around displaying normal fuel utilization for weighty vehicles during the activity and upkeep stage. As a rule, methods used to foster models for fuel utilization fall under three fundamental classifications:

- Physical science-based models, which are gotten from an in-depth comprehension of the actual framework. These models portray the elements of the parts of the vehicle at each time step utilizing nitty gritty numerical conditions
- AI models, which are information driven and address a conceptual planning from an info space comprising of a chosen set of indicators to a result space that addresses the objective result, for this situation normal fuel utilization
- Factual models, which are likewise, information driven and lay out a planning between the likelihood circulation of a chose set of indicators also, the objective result

Compromises among the above methods are principally regarding cost also, exactness according to the necessities of the planned application. Several previous models for both instantaneous and average fuel consumption have been proposed. Physics-based models are best suited for predicting instantaneous fuel consumption because they can capture the dynamics of the behavior of the system at different time steps. Machine learning models are not able to predict instantaneous fuel consumption with a high level of accuracy because of the difficulty associated with identifying patterns in instantaneous data. However, these models are able to identify and learn trends in average fuel consumption with an adequate level of accuracy. Previously proposed machine learning models for average fuel consumption use a set of predictors that are collected over a time period to predict the corresponding fuel consumption in terms of either gallons per mile or liters per kilometer. While still focusing on average fuel consumption, our 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. In contrast, previous machine learning models must not only learn the patterns in the input data but also perform a conversion from the time-based scale of the input domain to the distance-based scale of the output domain (i.e., average fuel consumption).



Involving similar scale for both the info and result spaces of the model offers a few advantages:

- Information is gathered at a rate that is corresponding to its effect on the result. At the point when the info space is tested as for time, how much information gathered from a vehicle at a stop is equivalent to how much data to gathered when the vehicle is moving.
- The indicators in the model can catch the effect of both the obligation cycle and the climate on the normal fuel utilization of the vehicle (e.g., the quantity of stops in a metropolitan rush hour gridlock over a given distance).
- Information from crude sensors can be collected on-board into not many indicators with lower capacity and transmission transfer speed necessities. Given the expansion in computational capacities of new vehicles, information rundown is best performed locally available close to the wellspring of the

1.2 PROJECT SCOPE:

This project aims to develop a machine learning model for predicting the average fuel consumption in heavy vehicles. The scope includes data collection and preparation, feature selection and engineering, model selection, training and evaluation, model interpretation, deployment and integration, documentation and reporting, as well as maintenance and future improvements. The project will involve gathering relevant data on variables such as vehicle specifications and driving conditions, preprocessing the data, selecting and engineering features, training and evaluating different machine learning algorithms, interpreting the trained model to understand feature importance, deploying the model in a user-friendly application or API, documenting the entire project, and establishing a plan for maintenance and future updates. The project's ultimate goal is to provide stakeholders with accurate predictions of fuel consumption, enabling them to optimize heavy vehicle efficiency and reduce fuel costs.

1.3 PROJECT OVERVIEW:

Machine learning is an area with a huge potential for the transformation of many areas of life and science including industrial informatics. In order to hasten the application of machine learning to real-world problems, the automated machine learning (AutoML) approach has been proposed. This article extends the Auto ML approach with the data-driven methodology applied to industrial problems with existing (e.g., model-based) solutions. When implementing these steps economic and environmental aspects should be taken into account. Waste transportation greatly affects both aspects and its optimization can significantly increase the positive effects. At the same time, there is a clear requirement that in order to keep recycling stations clean they should be emptied at a right time. It is non-trivial to fulfil this requirement in a scenario with several hundreds of recycling stations (each with several containers) that are spread over a large geographical area.

Collection of data, which can be used during the development and evaluation of solutions; The collected data are used to evaluate the existing solution to the problem; Parameters of the existing solution are optimized and evaluated based on the data; Conventional machine learning algorithms can be applied to the problem; The feature engineering methods are used to find if additional features could improve the results of the machine learning algorithms.

MACHINE LEARNING (ML):

Machine Learning (ML) is that field of computer science with the help of which computer systems can provide sense to data in much the same way as human beings do. In simple words, ML is a type of artificial intelligence that extract patterns out of raw data by using an algorithm or method. The main focus of ML is to allow computer systems learn from experience without being explicitly programmed.

Need for Machine Learning:

Human beings, at this moment, are the most intelligent and advanced species on earthbecause they can think, evaluate and solve complex problems. On the other side, AI is still in its initial stage and haven’t surpassed human intelligence in many aspects.Then the question is that what is the need to make machine learn? The most suitablereason for doing this is, “to make decisions, based on data, with efficiency and scale”. Lately, organizations are investing heavily in newer technologies like Artificial Intelligence, Machine Learning and Deep Learning to get the key information from data to perform several real-world tasks and solve problems. We can call it data- driven decisions taken by machines, particularly to automate the process. These data-driven decisions can be used, instead of using programing logic, in the problems that cannot be programmed inherently. The fact is that we can’t do without human intelligence, but other aspect is that we all need to solve real-world problems with efficiency at a huge scale. That is why the need for machine learning arises.

1.4 CHALLENGES IN MACHINE LEARNING:

While Machine Learning is rapidly evolving, making significant strides with cybersecurity and autonomous cars, this segment of AI as whole still has a long way to go. The reason behind is that ML has not been able to overcome number of challenges.

The challenges that ML is facing currently are:

Quality of data: Having good-quality data for ML algorithms is one of the biggest challenges. Use of low-quality data leads to the problems related to data preprocessing and feature extraction.

Time-Consuming task: Another challenge faced by ML models is the consumption of time especially for data acquisition, feature extraction and retrieval.

Lack of specialist persons: As ML technology is still in its infancy stage, availability of expert resources is a tough job.

No clear objective for formulating business problems: Having no clear objective andwell-defined goal for business problems is another key challenge for ML because this technology is not that mature yet.

Issue of overfitting & underfitting: If the model is overfitting or underfitting, it cannot be represented well for the problem.

Curse of dimensionality: Another challenge ML model faces is too many features ofdata points. This can be a real hindrance.

Difficulty in deployment: Complexity of the ML model makes it quite difficult to be deployed in real life

APPLICATIONS OF MACHINE LEARNING:

Machine Learning is the most rapidly growing technology and according to researchers we are in the golden year of AI and ML. It is used to solve many real- world complex problems which cannot be solved with traditional approach. Following are some real-world applications of ML:

- Emotion analysis
- Sentiment analysis
- Error detection and prevention
- Weather forecasting and prediction
- Stock market analysis and forecasting
- Speech recognition

- Customer segmentation

NumPy:

It is another useful component that makes Python as one of the favorite languages for Data Science. It basically stands for Numerical Python and consists of multidimensional array objects. By using NumPy, we can perform the following important operations:

- Mathematical and logical operations on arrays.
- Fourier transformation
- Operations associated with linear algebra.

We can also see NumPy as the replacement of MatLab because NumPy is mostly used along with SciPy (Scientific Python) and Mat-potlid (plotting library).

Installation and Execution If you are using Anaconda distribution, then no need to install NumPy separately as it is already installed with it. You just need to import the package into you Python script with the help of following:

- ➢ import numpy as np

On the other hand, if you are using standard Python distribution then NumPy can be installed using popular python package installer, pip.

- ➢ pip install NumPy

Pandas:

It is another useful Python library that makes Python one of the favorite languagesfor Data Science. Pandas is basically used for data manipulation, wrangling and analysis. It was developed by Wes McKinney in 2008. With the help of Pandas,

in data processing we can accomplish the following five steps:

- ➢ Load
- ➢ Prepare
- ➢ Manipulate
- ➢ Model
- ➢ Analyze

Data representation in Pandas:

The entire representation of data in Pandas is done with the help of following three data structures: Series: It is basically a one-dimensional array with an axis label which means it is like a simple array with homogeneous data. For example, the following series is a collection of integers 1,5,10,15,24,25…

data frame work:

It is the most useful data structure and used for almost all kind of data representation and manipulation in pandas. It is basically a two-dimensional data structure which can contain heterogeneous data.

Panel: It is a 3-dimensional data structure containing heterogeneous data. It is very difficult to represent the panel in graphical representation, but it can be illustrated as a container of Data Frame Installation and Execution If you are using Anaconda distribution, then no need to install Pandas separately as it is already installed with it. You just need to import the package into your

Python script with the help of following:

- import pandas as pd

On the other hand, if you are using standard Python distribution then Pandas can beinstalled using popular python package installer, pip.

- pip install Pandas

MATPLOTLIB:

Conventionally, the package is imported into the Python script by adding the following statement

- from matplotlib import pyplot as plt

Understanding matplotlib's pyplot API is key to understanding how to work with plots:

matplotlib.pyplot.figure : Figure is the top-level container. It includes everything visualized in a plot including one or more Axes.

matplotlib.pyplot.axes : Axes contain most of the elements in a plot: Axis, Tick, Line2D, Text, etc., and sets the coordinates. It is the area in which data is plotted. Axes include the X-Axis, Y-Axis, and possibly a Z-Axis, as well.

CHAPTER-2

LITERATURE SURVEY

2.LITERATURE SURVEY

2.1 INTRODUCTION

Literature survey is the most important step in software development process. Before developing the tool, it is necessary to determine the time factor, economy and company strength. Once these things are satisfied, then next steps are to determine which operating system and language used for developing the tool. Once the programmers start building the tool, the programmers need lot of external support. This obtained from senior programmers, from book or from websites. Before building the system the above consideration r taken into account for developing the proposed system.

2.2 RELATED WORK

1) Development of greenhouse gas emissions model for 2014-2017 heavy-and medium-duty vehicle compliance:

Vehicles of light-obligation families are dependent upon obligatory testing for certificate and consistence. Not at all like the light-obligation area where a greater part of vehicles is efficiently manufactured for commonly comparable purposes, medium-and uncompromising vehicles are regularly specially crafted. Stages of motors, transmissions, axles, case outlines, assistant gear, and various other explicit purchaser necessities have brought about tens or many great many truck designs for some truck classes or applications in the armada for some random year. To assist with dealing with the administrative testing trouble on truck producers and the public authority organizations, the Natural Assurance Organization has made the Ozone depleting substance Discharges Model which is to be mutually involved by the two offices as the essential instrument to guarantee professional and mix work vehicle substantial vehicles (Class 2b through Class 8 uncompromising, barring uncompromising pickups or vans). This paper portrays the reproduction device, including fundamental elements and suspicions utilized in apparatus improvement. The model has been approved utilizing Class 7 and Class 8 mix farm truck information got from case dynamometer testing and benchmarked against a broadly accessible business vehicle re-enactment instrument

2) Monitoring co2 emissions from hdv in Europe an experimental proof of concept of the proposed methodological approach:

The European Commission in joint cooperation with Substantial Vehicle fabricates, the Graz College of Innovation and other counselling and research bodies has been setting up a new official system for checking and detailing CO2emanations from Uncompromising Vehicles (HDVs) in Europe. Rather than traveller vehicles and light business vehicles, for which observing is performed through skeleton dyno estimations, and taking into account the variety and specific qualities of the HDV market, it was chosen that the centre of the proposed procedure ought to be in view of a mix of part testing and vehicle re-enactment. Accentuation is placed on precisely reproducing the presentation of various vehicle parts and accomplishing reasonable fuel utilization results. A proof of idea was sent off meaning to verify that these objectives are feasible. A series of examinations were led on 2 unique trucks, a Daimler 40ton Euro VI, long stretch conveyance truck with semi-trailer and a DAF 18-ton Euro Vin flexible truck. Estimations were performed at the Joint Exploration Place's HDV frame dyno labs and out and about. A vehicle test system (Vehicle Energy Utilization Estimation Apparatus - VECTO) has been created to be utilized for true observing purposes what's more, the aftereffects of the estimations were utilized for its approval.

3) Fuel consumption prediction of fleet vehicles using machine learning: A comparative study:

Capacity to show and foresee the fuel utilization is crucial in upgrading efficiency of vehicles and

forestalling fake exercises in armada the executives. Fuel utilization of a vehicle relies upon a few

inward factors like distance, load, vehicle attributes, and driver conduct, as well as outside elements, for example, street conditions, traffic, and climate. Be that as it may, not this multitude of variables might be estimated or accessible for the fuel utilization examination. We consider a situation where just a subset of the previously mentioned factors is accessible as a multivariate time series from a significant distance, public transport. Consequently, the test is to show or potentially anticipate the

fuel utilization just with the accessible information, while still by implication catching as much as impacts from other inside and outside factors. AI(ML) is appropriate in such examination, as the model can be created by learning the examples in information. In this paper, we look at the prescient capacity of three Strategies in anticipating the fuel utilization of the transport, considering all suitable boundaries as a period series. In view of the examination, it very well may be reasoned that the irregular backwoods method creates a more precise forecast contrasted with both the angle helping furthermore, brain organizations.

4) Modelling heavy/medium duty fuel consumption based on drive cycle properties:

This paper presents numerous techniques for anticipating weighty/medium-obligation vehicle fuel utilization based on driving cycle data. A polynomial model, a black box counterfeit brain net model, a polynomial brain network model, and a multivariate versatile relapse splines (MARS) model were created also, checked utilizing information gathered from body testing performed on a package conveyance diesel truck working over the Weighty Uncompromising Diesel Truck (HHDDT),City Rural Weighty Vehicle Cycle (CSHVC), New York Composite Cycle (NYCC), and water powered crossover vehicle (HHV) drive cycles. Each model was prepared utilizing one of four drive cycles as a preparation cycle and the other three as testing cycles. By looking at the preparation and testing results, agent preparing cycle was picked and used to further tune every strategy. HHDDT as the preparation cycle gave the best prescient outcomes, on the grounds that HHDDT contains an assortment of drive qualities, like rapid, speed increase, sitting, and deceleration. Among the four model methodologies, MARS gave the best prescient presentation, with a normal percent blunder of −1.84% over the four case dynamometer drive cycles. To additionally assess the precision of the prescient models, the methodologies were applied to true information. MARS beat the other three methodologies, giving a normal percent blunder of −2.2% more than four genuine street sections. The MARS model execution was then, at that point, contrasted with powertrain demonstrating results over HHDDT, CSHVC, NYCC, and HHV drive cycles utilizing NREL's Future Auto Frameworks Innovation Test system (FAST Sim). The outcomes shown that the MARS technique accomplished equivalent prescient execution with FAST Sim.

5) Application of machine learning for fuel consumption modelling of trucks:

This paper presents the use of three Machine Learning methods to fuel utilization demonstrating of explained trucks for an enormous dataset. Specifically, Support Vector Machine (SVM), Irregular Woods(RF), and Counterfeit Brain Organization (ANN) models have been produced for the reason and their execution thought about. Armada chiefs use telematic information to screen the presentation of their armadas and take choices in regards to upkeep of the vehicles what’s more, preparing of their drivers. The information, which incorporate fuel utilization, are gathered by standard sensors(SAE J1939) for current vehicles. Information with respect to the attributes of the street come from the Interstates Organization Asphalt The board Framework (HAPMS) of Thruways Britain, the supervisor of the essential street network in the UK. Together, this information can be utilized to foster another fuel utilization model, which may assist with transitory directors in checking on the current vehicle steering choices, in view of street calculation. The model would likewise be valuable for street directors to better grasp the fuel utilization of street vehicles and the impact of street math. Ten times cross-approval has been performed to prepare the SVM, RF, and ANN models. Aftereffects of the review shows the attainability of utilizing telematic information together with the data in HAPMS with the end goal of displaying fuel utilization. The concentrate likewise shows that albeit every one of the three techniques make it conceivable to foster models with great accuracy, the RF marginally outflanks SVM and ANN giving higher R-squared, and lower blunder.

CHAPTER-3

SYSTEM ANALYSIS

3. SYSTEM ANALYSIS

3.1 FEASIBILITY STUDY

Feasibility study is accompanied once the difficult is obviously understood. The feasibility study which is a great level lozenge version of the whole system analysis and design procedure. The independent is to define whether the planned system is possible or not and it benefits us to the least expense of how to resolve the problem and to govern, if the Problem is wealth solving.

The following are the three important tests that have been conceded out for feasibility Study.

- Technical Feasibility
- Economic feasibility
- Operational feasibility

3.1.1 TECHNICAL FEASIBILITY

In the technical feasibility study, one has to assess whether the implemented system can be established using existing technology or not. It is intended to implement the implemented system in JSP. The project enabled is theoretically feasible since the following reasons.

- All needed technology exists to improve the system.
- The existing system is so malleable that it can be advanced further.

3.1.2 ECONOMIC FEASIBILITY

As a portion of this, the expenses and profits related with the implemented systems are to be associated. The project is carefully feasible only if tangible and intangible assistances balance the cost. We can say the implemented system is feasible founded on the following grounds.

- The charge of developing the filled system is sensible.
- The cost of hardware and software for the application is less

3.1.3 OPERATIONAL FEASIBILITY

This project is operationally feasible for there is necessary support from the project organization and the users of the implemented system Implemented system absolutely does not damage and determination not create the corrupt results and no problem will ascend after Search document implementation of the system.

User-friendly:

Customer will use the forms for their various transactions i.e.. for adding new routes, viewing the routes details. Also, the Customer wants the reports to view the various transactions based on the constraints. These forms and reports are generated as user-friendly to the Client.

Reliability:

The package wills pick-up current transactions on line. Regarding the old transactions, User will enter them in to the system.

Security:

The web server and database server should be protected from hacking, virus etc.

3.2 Software Description:

3.2.1 Python Technology

Python technology is both programming language and a platform.

3.2.2 The Python Programming Language

PYTHON

Python is a high-level, interpreted, interactive and object-oriented scripting language. Python is designed to be highly readable. It uses English keywords frequently where as other languages use punctuation, and it has fewer syntactical constructions than other languages.

- **Python is Interpreted:** Python is processed at runtime by the interpreter. You donot need to compile your program before executing it. This is similar to PERL and PHP.
- **Python is Interactive:** You can actually sit at a Python prompt and interact withthe interpreter directly to write your programs.
- **Python is Object-Oriented:** Python supports Object-Oriented style or technique of programming that encapsulates code within objects.
- **Python is a Beginner's Language:** Python is a great language for the beginner-level programmers and supports the development of a wide range of applicationsfrom simple text processing to WWW browsers to games.

History of Python

Python was developed by Guido van Rossum in the late eighties and early nineties at the National Research Institute for Mathematics and Computer Science in the Netherlands.

Python is derived from many other languages, including ABC, Modula-3, C, C++, Algol-68, Smalltalk, and Unix shell and other scripting languages.

Python is copyrighted. Like Perl, Python source code is now available under the GNU General Public License (GPL) Python is now maintained by a core development team at the institute, althoughGuido van Rossum still holds a vital role in directing its progress.

Python Features

Python's features include:

- **Easy-to-learn:** Python has few keywords, simple structure, and a clearly defined syntax. This allows the student to pick up the language quickly.
- **Easy-to-read:** Python code is more clearly defined and visible to the eyes.
- **Easy-to-maintain:** Python's source code is fairly easy-to-maintain.
- **A broad standard library:** Python's bulk of the library is very portable and cross-platform compatible on UNIX, Windows, and Macintosh
- **Interactive Mode:** Python has support for an interactive mode which allows

interactive testing and debugging of snippets of code.

- **Portable:** Python can run on a wide variety of hardware platforms and has the same interface on all platforms.
- **Extendable:** You can add low-level modules to the Python interpreter. These modules enable programmers to add to or customize their tools to be more efficient.
- **Databases:** Python provides interfaces to all major commercial databases.
- **GUI Programming:** Python supports GUI applications that can be created and ported to many system calls, libraries and windows systems, such as Windows MFC, Macintosh, and the X Window system of Unix.
- **Scalable:** Python provides a better structure and support for large programs than shell scripting.

Python has a big list of good features:

- It supports functional and structured programming methods as well as OOP.
- It can be used as a scripting language or can be compiled to byte-code for building large applications.
- It provides very high-level dynamic data types and supports dynamic typechecking.
- IT supports automatic garbage collection.

3.3 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.

Compromises among the above procedures are basically as for cost and exactness according to the necessities of the expected application. In this paper, a model that can be handily created for individual weighty vehicles in an enormous armada is proposed. Depending on exact models of every one of the vehicles in an armada, an armada chief can improve the course anticipating every one of the vehicles in light of every special vehicle anticipated fuel utilization in this manner guaranteeing the course tasks are adjusted to limit generally speaking armada fuel utilization. These kinds of armadas exist in different areas including, street transportation of merchandise , public transportation ,development trucks and deny trucks. For each armada, the philosophy should apply and adjust to various vehicle advancements (counting future ones) and arrangements without definite information on the vehicle’s explicit actual attributes and estimations. These prerequisites pursue AI the strategy of decision while thinking about the ideal exactness versus the cost to of the turn of events and transformation of an individualized model for every vehicle in the armada.

DISADVANTAGES OF EXISTING SYSTEM

1. Lack of Accuracy: The existing system may not provide accurate measurements of fuel consumption. It may rely on manual calculations or estimations, leading to potential errors and inaccuracies in the recorded data.
2. Limited Data Collection: The current system may not collect sufficient data points to accurately calculate the average fuel consumption. It might only consider a few factors such as distance traveled or fuel refills, neglecting other crucial variables that can affect fuel efficiency, such as vehicle weight, driving conditions, and cargo load.

3.4 PROPOSED SYSTEM

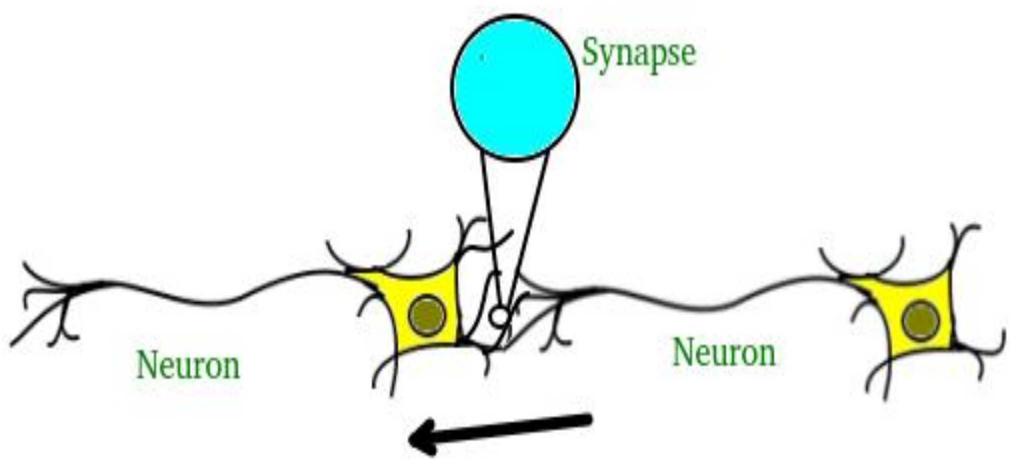
Artificial Neural Network (ANN) are frequently used to foster computerized models for complex frameworks. The models proposed in feature a portion of the troubles looked by AI models when the info and result have various spaces. In this review, the information is accumulated in the time area north of 10 minutes stretches and the result is fuel utilization over the distance went during a similar time span. The intricate framework is addressed by an exchange capability $F(p) = o$, where $F(\cdot)$ addresses the framework, p alludes to the information indicators and o is the reaction of the framework or the result. The ANNs utilized in this paper are Feed Forward Brain Organizations (FNN). Preparing is an iterative cycle and can be performed utilizing different methodologies including molecule swarm enhancement and back proliferation. Different methodologies will be viewed as in future work to assessment their capacity to work on the model's prescient exactness. Every cycle in the preparation chooses a couple of (input, yield) highlights from Ftr aimlessly and refreshes the loads in the organization. This is finished by ascertaining the mistake between the real result esteem and the worth anticipated by the model.

ADVANTAGES OF PROPOSED SYSTEM:

- Information is gathered at a rate that is relative to its effect on the result. At the point when the info space is examined concerning time, how much information gathered from a vehicle at a stop is equivalent to how much information gathered when the vehicle is moving.
- The indicators in the model can catch the effect of both the obligation cycle and the climate on the normal fuel utilization of the vehicle (e.g., the quantity of stops in a metropolitan rush hour gridlock over a given distance).
- Information from crude sensors can be collected on-board into not many indicators with lower capacity and transmission transfer speed prerequisites. Given the expansion in computational capacities of new vehicles, information outline is best performed locally available close to the wellspring of the information.

3.5 ANN ALGORITHM:

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired the brain. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning largely involves adjustments to the synaptic connections that exist between the neurons



The brain consists of hundreds of billions of cells called neurons. These neurons are connected together by synapses which are nothing but the connections across which a neuron can send an impulse to another neuron. When a neuron sends an excitatory signal to another neuron, then this signal will be added to all of the other inputs of that neuron. If it exceeds a given threshold then it will cause the target neuron to fire an action signal forward — this is how the thinking process works internally.

In Computer Science, we model this process by creating “networks” on a computer using matrices. These networks can be understood as an abstraction of neurons without all the biological complexities taken into account. To keep things simple, we will just model a simple NN, with two layers capable of solving a linear classification problem.

ANN Working Procedure

To demonstrate the way to build associate ANN neural network primarily based image classifier, we tend to shall build a vi-layer neural network that may establish and separate one image from alternative. This network that we tend to shall build may be a terribly little network that we are able to run on a CPU additionally. ancient neural networks that square measure excellent at doing image classification have more parameters and take plenty of your time if trained on traditional CPU. However, our objective is to point out the way to build a real-world convolutional neural network exploitation TENSORFLOW. Neural Networks square measure primarily mathematical models to resolve associate improvement drawback. they're made from neurons, the fundamental computation unit of neural networks. A nerve cell takes associate input (say x), do some computation thereon (say: multiply it with a variable w and adds another variable b) to provide a worth (say; z= wx + b). This price is passed to a non-linear perform referred to as activation perform (f) to provide the ultimate output (activation) of a nerve cell. There square measure several varieties of activation functions. one in all the popular activation perform is Sigmoid. The nerve cell that uses sigmoid perform as associate activation perform are going to be referred to as sigmoid nerve cell. betting on the activation functions, neurons square measure named and there square measure several varieties of them like RELU, TanH. If you stack neurons in a very single line, it’s referred to as a layer; that is that the next building block of neural networks. See below image with layers To predict image category multiple layers operate one another to induce best match layer and this method continues until no additional improvement left. Modules info This project consists of following modules Upload serious Vehicles Fuel Dataset: exploitation this module we are able to transfer train dataset to application. Dataset contains comma separated values. Read Dataset & Generate Model: exploitation this module we are going to take apart comma separated dataset and so generate train and check model for ANN from that dataset values. Dataset are going to be divided into eightieth and two hundredth format, eightieth are going to be wont to train ANN model and two hundredth are going to be wont to check ANN model. Run ANN Algorithm: exploitation this model we are able to produce ANN object and so feed train and check information to create ANN model. Predict Average Fuel Consumption: exploitation this module can|we'll|we are going to} transfer new check information and so ANN will apply train model thereon check information to predict average fuel consumption for that check records. Fuel Consumption Graph: exploitation this module we are going to plot fuel consumption graph for every check record

3.6 System Modules

Implementation is the stage where the theoretical design is converted into programmatically manner. In this stage we will divide the application into a number of modules and then coded for deployment. The front end of the application takes HTML,CSS and as a we took MY SQL database.
The application is divided into following 4 modules: They are as follows

1) Data collection And Summarization

2) Model Predictors

3) Model Output

4) Model Validation

Now let us discuss about each and every module in detail

MODULE DESCRIPTION:

3.5.1 Data collection And Summarization

Upload Heavy Vehicles Fuel Dataset:

Using this module, we can upload train dataset to application. Dataset contains comma separated values.
The model is created by utilizing obligation cycles gathered from a single truck, with an estimated mass of 8,700kg presented to an assortment of drifters including both urban and expressway traffic in the Indianapolis region. Information was gathered utilizing the SAE J1939standard for sequential control and correspondences in rock solid vehicle organizations. Twelve drivers were approached to show positive or negative way of behaving over two distinct courses. Drivers displaying acceptable conduct expected to slow down and permitted the vehicle to drift when conceivable. A few drivers participated more than others and as a result the dissemination of drivers and courses isn't uniform across the informational collection. This field test produced 3, 302, 890 data of interest examined at 50 Hz from the vehicle CAN transport and an all-out distance of 778.89km north of 56 excursions with shifting distances. The greater part of the trip covered a distance of 10 km to 15 km. To build the quantity of data of interest, engineered obligation cycles over a drawn-out distance were gotten by collecting fragments from the field obligation cycles chose aimlessly. Besides, a bunch of drivers are doled out to the training portions what’s more, an alternate arrangement of drivers is relegated to the testing sections, consequently guaranteeing that the preparation

(Ftr) and testing (Fts) informational collections determined from the individual sections are totally different.

3.5.2 Model Predictors

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

A few handling steps were required to produce the indicators of the model. These indicators are gotten from two estimations, in particular, street level and transmission yield speed. The primary handling step comprised of down inspecting the street level and getting the vehicle speed from the transmission yield speed. The street level was estimated utilizing an on-board inclinometer and down-inspected to 1 Hz. A survey of the information likewise showed that there is a direct relationship between the vehicle speed and the transmission yield speed given by the accompanying condition:

$$\text{Vehicle Speed} \approx 59.3 \times \text{Transmission Result Speed}$$

To decrease the clam or in the variable, a moving normal low pass channel was applied to the vehicle speed got by utilizing and the variable was down-sampled from 50 Hz to 1 Hz. The reason for the subsequent handling step was to infer the engineered obligation cycles. Towards this goal, the obligation cycles in the genuine information were parted into fragments characterized by stretches between continuous vehicle stops (Figure 1). A sum of 455 genuine information sections were gotten from every one of the twelve drivers in the review. Out of these, 358 sections from nine drivers were utilized to infer the preparation informational index and the leftover 97 portions, got from the leftover three drivers in the review, were used to determine the testing informational index Fts.

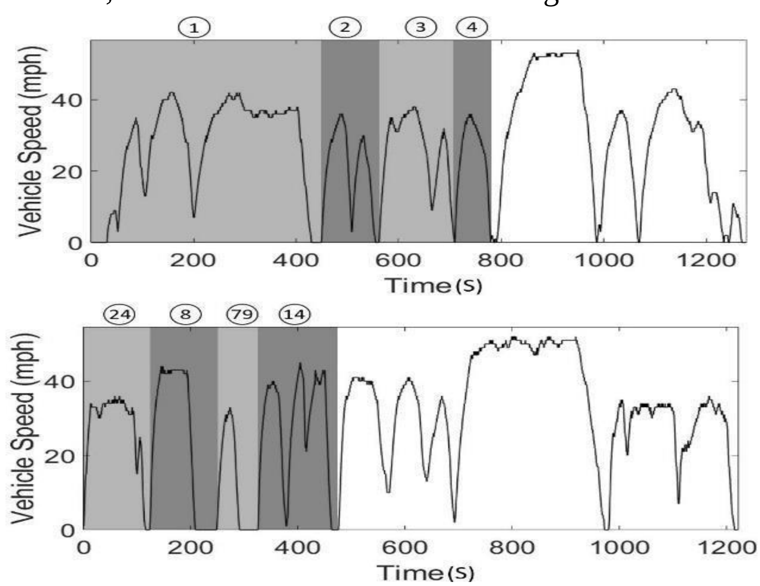


Fig.1. The first four segments of a sample real duty cycle (top). A sample synthetic duty cycle created by concatenating segments 24, 8, 79, and 14 from the real data (bottom)

One engineered obligation cycle is created by testing, without substitution, from the genuine information sections and connecting the chosen sections until a complete distance of 15 km is reached. The absolute distance of 15 km was chosen to impersonate the genuine courses utilized for the field data assortment. It was seen that as abnormal of five sections are expected to make 15 km of information. Figure 1 shows a model manufactured obligation cycle produced utilizing this interaction. Joining portions utilizing the above approach brought about a persistent vehicle speed. In any case, discontinuities were seen in street level starting with one section then onto the next as displayed in the case of Figure 2. These obligation cycles are teetotaller over a fixed distance traveled in view of the ideal window (x). Table I shows the complete number of data of interest (i.e., windows) as well as the all-out distance for every informational collection and forevery window size being viewed as in this paper. The third stepin the information handling comprises of creating the indicators for the proposed model. As recently referenced, these indicators are determined for every window and got from vehicle speed and street level. The chose predictors consist of:

• number of stops.
• time halted.

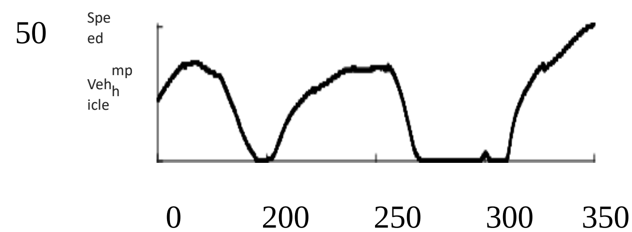


TABLE I:

NUMBER OF DATA POINTS (I.E., WINDOWS) AND TOTAL DISTANCE FOR THE TRAINING (F(x)tr) AND THE TESTING (F(x)ts) DATA SETS WITH VARYING SIZE WINDOWS (I.E., 1, 2, AND 5 km.)

- average moving speed,
- characteristic acceleration,
- aerodynamic speed squared,
- change in kinetic energy and change in potential energy.

The on top of indicators were chosen because of their accepted to catch the vehicle elements moreover in light of the fact that the driver's way of behaving and furthermore the effect of the course on the objective result of the model (i.e., fuel utilization). particularly, a past report expresses that trademark speed increase and mechanics speed square region unit incredibly demonstrative of the fuel utilization for a given obligation cycle. This study contends that trademark speed increase is straightforwardly connected with the idleness work expected to speed up the vehicle and mechanics speed square catches the effect of aeromechanics on fuel utilization .

It is critical to catch the adjustment of active and likely energy during the obligation cycle on the grounds that these progressions in the energy condition of the vehicle can be huge for brief distances when contrasted with how much complete energy consumed by fuel. Over a lengthy distance, the level of fuel energy switched over completely to motor as well as potential energy is diminished.

3.5.3 Model Output

Fuel Consumption Graph:

Using this module, we will plot fuel consumption graph for each test record.
In above test data class value as fuel consumption is not there and when we applied this test record on ANN model then ANN will predict fuel consumption class value for that test record. Entire train and test data available inside ‘dataset ‘folder.
The result of the model is normal fuel utilization in l/100km for each window. in order to get the normal utilization, fuel rates region unit gathered from the will transport. As inside the instance of street level, and since counterfeit obligation cycles region unit got from an irregular decision of genuine obligation cycle portions, discontinuities inside the fuel rate region unit found from one stage to progressive (Figure 2). The effect of those discontinuities isn't significant because of the fuel rates region unit arrived at the midpoint of over the total window in order to work out the result of the model (i.e., normal fuel utilization).
An examination of the sections in the genuine information gathered from the field shows a difference in normal fuel utilization over every one of the outings. For instance, a 20% distinction in fuel utilization was seen among great and terrible driver conduct over whole excursions. Additionally, fluctuations in normal fuel utilization are likewise noticed for various window sizes.
Table II shows the mean and standard deviation of the typical fuel utilization for the 1, 2, and 5 km windows across all excursions. While the mean fuel utilization across all windows is generally consistent, the standard deviation diminishes as the window size increments.
In outline, every one of the information highlights of the proposed model are determined utilizing the above procedure from the vehicle speed and the street level examined at a pace of 1 Hz. These factors can be gotten from a telematics gadget. In this review, these factors were gotten from sensor values communicated on the CAN transport. The exactness of the model will change contingent upon the wellspring of the information and the examining recurrence. The precision of the model is likewise dependent upon the exactness of the result include. Fuel utilization acquired from the CAN transport can have a blunder as high as 5% contrasted with the real fuel utilization. Better precision can be acquired by utilizing flowmeters. Notwithstanding, flowmeters are more costly. Fuel utilization levels from the CAN transport are utilized as well as in this paper and high accuracy fuel sensors are utilized. Viewpoints connected with the exactness of the information sources will be investigated in future work.

3.5.4 Model Validation

Run ANN Algorithm

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. Using this module, we can create ann object and then feed train and test data to build ANN model.
The seven indicators recorded in Segment IV are utilized as contribution to the brain network model. This is the principal layer of the organization. The primary layer then, at that point, takes care of into a secret layer with 5 neurons. Thusly, the secret layer takes care of into a result player with a solitary neuron. Figure 3 shows the RMSE during preparing for three models with window sizes 1, 2 and 5 km. In the top plot, every information point compares to the RMSE values subsequent to preparing the model with a gathering of 500 windows.

This plot demonstrates that all models unite to a RMSE esteem under 0.2 l/100km. Be that as it may, the union rates for the models are unique. As a matter of fact, the 5 km begins with a RMSE worth of 0.16 l/100km after 500 preparation windows and this RMSE esteem arrives at 0.08 l/100km when the model joins. The comparing values for the 1 km model are 0.34 l/100km and 0.14 l/100km, separately.

When combined with the distinction in standard deviation of the typical fuel utilization for the 1 km and the 5 km windows (Table II), this pattern demonstrates that conglomerating the info and result information more than 5 km gives a steady profile to the fuel utilization of the vehicle over the courses and this profile doesn't require broad learning.

This finding lines up with past investigations.

For example, it was found that the outing distance is a significant pointer and that foreseeing fuel utilization over lengthy course portions for little vehicles in metropolitan regions has better exactness. In this past review, 64% of the excursions covered a distance ≤ 5 km. Likewise, it was found that gathering information north of 10 minutes spans brought about a preferable precision over brief stretches. Regardless, we accept that expanding the information assortment span advances a direct connection between fuel utilization and distance voyaged. While this approach yields a decent typical fuel utilization expectation over significant distances, point-wise anticipated fuel utilization may not sufficiently track real qualities.

TABLE II

PREDICTIVE ACCURACY OF THE FUEL CONSUMPTION MODELS FOR 1, 2 AND 5 km AGGREGATION WINDOWS.

Window	1 *km*	2 *km*	**5 *km***
CD	0.91 (0.0066)	0.87 (0.0085)	0.79 (0.0136)
RMSE (l/100km)	0.0132 (0.0005)	0.0142 (0.0005)	0.0234 (0.0008)
MAE (l/100km)	1.88 (0.0626)	1.69 (0.0515)	1.43 (0.0466)
MAPEpk	3.74% (0.12%)	4.20% (0.13%)	5.83% (0.19%)
Points	32,089	23,106	6,061

Table III shows that the 1 km model has preferable execution over the other two window sizes across all measurements. As recently referenced, these exhibition measurements assess the presentation of the model point-wise. Specifically, the coefficient of assurance (Album) for the 1 km model is equivalent to 0.91 which demonstrates that the model can follow the genuine fuel utilization for every 1 km of distance voyaged. As the window size builds, the Disc diminishes. As far as MAE and Cd, the proposed model shows an improvement over in spite of the way that high accuracy fuel sensors are utilized. The RMSE of the models is additionally under 0.025 l/100km which is lower than the outcomes got. All things considered, the test distance in this paper is higher than the one utilized. Longer distances favour lower RMSE

<u>TABLE III</u>

ADJUSTED INFLUENCE OF WEIGHTS (AIW) FOR THE PREDICTORS IN THE PROPOSED MODEL

Window	**1 *km***	**2 *km***	**5 *km***
No. of Stops Stop Time Avg. Moving Speed *a* ˜ *v*2 *aero* *CKE* *CPE* Bias	1.49 0.62 13.73 12.47 11.73 17.04 13.73 29.21	2.29 1.24 10.78 14.32 11.64 16.13 11.45 32.15	4.63 3.44 8.98 12.98 10.30 12.26 9.38 38.03

The Significance of the quantity of stops and the stop time increments as the window size increments. This is normal since less stops are seen in the 1 km window contrasted with the 2 or 5 km windows. Every one of the leftover indicators have high AIW across all window sizes. As a matter of fact, disposing of any of these indicators brought about models with lower prescient precision. The expansion in the AIWs for the quantity of stops and the stop time with expanding window sizes combined with the abatement in AIWs for the leftover indicators demonstrates that as the window size builds, the model depends less on the vehicle's elements and more on occasions connected with the distance ventured out to appraise fuel utilization.

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 such as

num_stops, time_stopped, average_moving_speed, characteristic_acceleration, aerodynamic_speed_squared,change_in_kinetic_energy, change_in_potential_energy, class

Above seven features are recorded from each vehicle travel up to 100 kilo meters like number of times vehicle stop, total stopped time taken etc. All this values are collected from heavy vehicle and use as dataset to train ANN model. Below are some value from above seven predictor features.

num_stops, time_stopped, average_moving_speed, characteristic_acceleration, aerodynamic_speed_squared, change_ in_kinetic_energy, change_in_potential_energy, class

7.0, 7.0, 93.0, 34, 8.4, 4, 25.6, 9
7.0, 7.0, 91.0, 34, 8.3, 4, 25.7, 9
8.9, 8.9, 151.0, 26, 10.9, 6, 15.1, 12
9.3, 9.3, 160.0, 25, 11.3, 6, 13.7, 13
8.4, 8.4, 158.0, 25, 11.2, 6, 13.8, 13

All bold names are the dataset column names and all double values are the dataset values for each vehicle. Last column will be considered as class name which represents fuel consumption for that vehicle. Entire dataset will be used to train ANN model and whenever we give new record then ANN algorithm will apply train model on that test record to predict it average fuel consumption.

Below are some test records

num_stops, time_stopped, average_moving_speed, characteristic_acceleration, aerodynamic_speed_squared, change_ in_kinetic_energy, change_in_potential_energy

7.0, 7.0, 93.0, 34, 8.4, 4, 25.6
7.0, 7.0, 91.0, 34, 8.3, 4, 25.7
8.9, 8.9, 151.0, 26, 10.9, 6, 15.1
9.3, 9.3, 160.0, 25, 11.3, 6, 13.7
8.4, 8.4, 158.0, 25, 11.2, 6, 13.8

In above test data class value as fuel consumption is not there and when we applied this test record on ANN model then ANN will predict fuel consumption class value for that test record. Entire train and test data available inside 'dataset' folder.
The ANN model is developed by using duty cycle's dataset collected from a single truck, with an approximate mass of 8, 700kg exposed to a variety of transients including both urban and highway traffic in the Indianapolis area. Data was collected using the SAE J1939 standard for serial control and communications in heavy duty vehicle networks.

CHAPTER-4
SYSTEM SPECIFICATION

4.SYSTEM SPECIFICATION

4.1 Software Requirement Specification:

A Software Requirements Specification (SRS) is a complete description of the behavior of the system to be developed. It includes a set of use cases that describe all the interactions the users will have with the software. Use cases are also known as functional requirements. In addition to use cases, the SRS also contains non-functional (or supplementary) requirements. Non-functional requirements are requirements which impose constraints on the design or implementation (such as performance engineering requirements, quality standards, or design constraints)

4.2 Functional Requirements:

In software engineering, a functional requirement defines a function of a software system or its component. A function is described as a set of inputs, the behavior, and outputs: Functional requirements may be calculations, technical details, data manipulation and processing and other specific functionality that define what a system is supposed to accomplish. Behavioral requirements describing all the cases where the system uses the functional requirements are captured in use cases Functional requirements are supported by non-functional requirements (also known as quality requirements), which impose constraints on the design or implementation (such as performance requirements, security, or reliability). How a system implements functional requirements is detailed in the system design. In some cases, a requirements analyst generates use cases after gathering and validating a set of functional requirements. Each use case illustrates behavioral scenarios through one or more functional requirements, Often, though, an analyst will begin by eliciting a set of use cases, from which the analyst can derive the functional requirements that must be implemented to allow a user to perform each use case

4.3 Non-Functional Requirements:

In systems engineering and requirements engineering, a non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors. This should be contrasted with functional requirements that define specific behavior or functions In general, functional requirements define what a system is supposed to do whereas non-functional requirements define how a system is supposed to be.

Non-functional requirements are often called qualities of a system. Other terms for non-functional requirements are constraints", "quality attributes", "quality goals" and "quality of service requirements," and "non-Behavioral requirements."[1] Qualities, is, non-functional requirements, can be divided into two main categories:

1. Execution qualities, such as security and usability, which are observable at run time.
2. Evolution qualities, such as testability, maintainability, extensibility and scalability, which are embodied in the static structure of the software system

Introduction:

To be used efficiently, all computer software needs certain hardware components or other software resources to be present on a computer. These pre-requisites are known as (computer) system requirements and are often used as a guideline as opposed to an absolute rule. Most software defines two sets of system requirements: minimum and recommended. With increasing demand for higher processing power and resources in newer versions of software, system requirements tend to increase over time.

Hardware Requirements:

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware. The following sub-sections discuss the various aspects of hardware requirements.

- **System** **:** Pentium IV or Higher.
- **Hard Disk** **:** 40 GB.
- **Floppy Drive** **:** 1.44 Mb.
- **Monitor** **:** 15'Inch Color Monitor.
- **Mouse** **:** Optical Mouse.
- **Ram** **:** 8 GB.

Software Requirements:

Software Requirements deal with defining software resource requirements and pre-requisites that need to be installed on a computer to provide optimal functioning of an application. These requirements or pre-requisites are generally not included in the software installation package and need to be installed separately before the software is installed.

- Domain: Python
- Version: Python IDLE (3.11.2)
- Code Editors: PyCharm
- Frameworks and Dependencies: tkinter,matplotlib,Keras,numpy,pandas
- Operating System: Windows 10

CHAPTER-5
SYSTEM DESIGN

5.SYSTEM DESIGN

5.1 SYSTEM ARCHITECTURE

Software design plays a crucial role in the software engineering process, serving as a central component regardless of the development paradigm or application domain. It serves as the initial step during the development phase of any engineered product or system. The primary objective of a designer is to create a model or representation of an entity that will be constructed later. Once system requirements have been specified and analyzed, system design marks the inception of the development process, preceding the subsequent technical activities of coding and testing, which are essential for constructing and validating software.

During the design phase, there is a continuous process of enhancing and refining data structures, program structures, and procedural details. These refinements are developed, reviewed, and documented. System design can be approached from both a technical and a project management perspective. From a technical standpoint, design encompasses four key activities: architectural design, data structure design, interface design, and procedural design.

5.2 UML DIAGRAMS :

UML stands for Unified Modeling Language. UML is a standardized general- purpose modeling language in the field of object-oriented software engineering. The standard is managed, and was created by, the Object Management Group.

The goal is for UML to become a common language for creating models of object-oriented computer software. In its current form UML is comprised of two major components: a Meta-model and a notation. In the future, some form of method of process may also be added to; or associated with, UML.

The Unified Modeling Language is a standard language for specifying, Visualization, Constructing and documenting the artifacts of software system, as well as for business modeling and other non-software systems.

The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems.

The UML is a very important part of developing objects-oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects.

GOALS:

The Primary goals in the design of the UML are as follows:

1. Provide users a ready-to-use, expressive visual modeling Language so that theycan develop and exchange meaningful models.

2. Provide extendibility and specialization mechanisms to extend the core concepts.
3. Be independent of particular programming languages and development process.
4. Provide a formal basis for understanding the modeling language.
5. Encourage the growth of OO tools market.
6. Support higher level development concepts such as collaborations, frameworks, patterns and components.
7. Integrate best practices.

5.2.1 USE CASE DIAGRAM:

A use case diagram in the Unified Modeling Language (UML) is a type of behavioural diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted

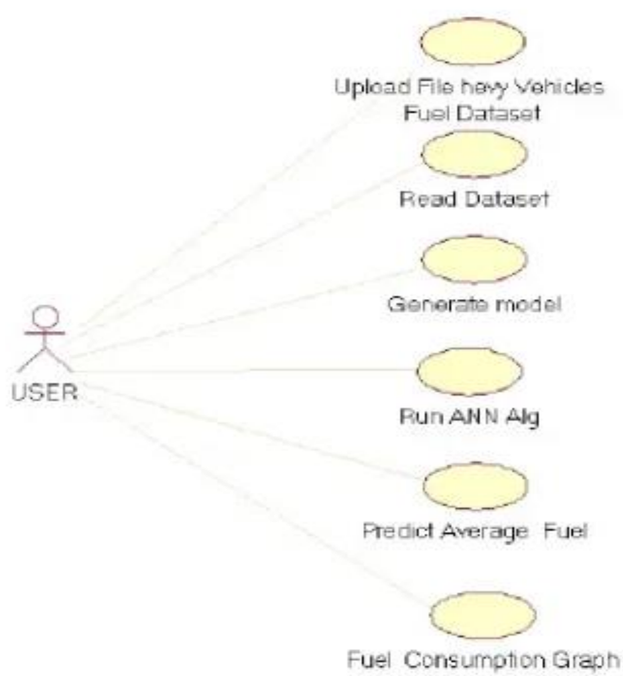


FIGURE 5.2.1 USE CASE DIGRAM

5.2.2 CLASS DIAGRAM:

In software engineering, a class diagram in the Unified Modeling Language (UML)is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.

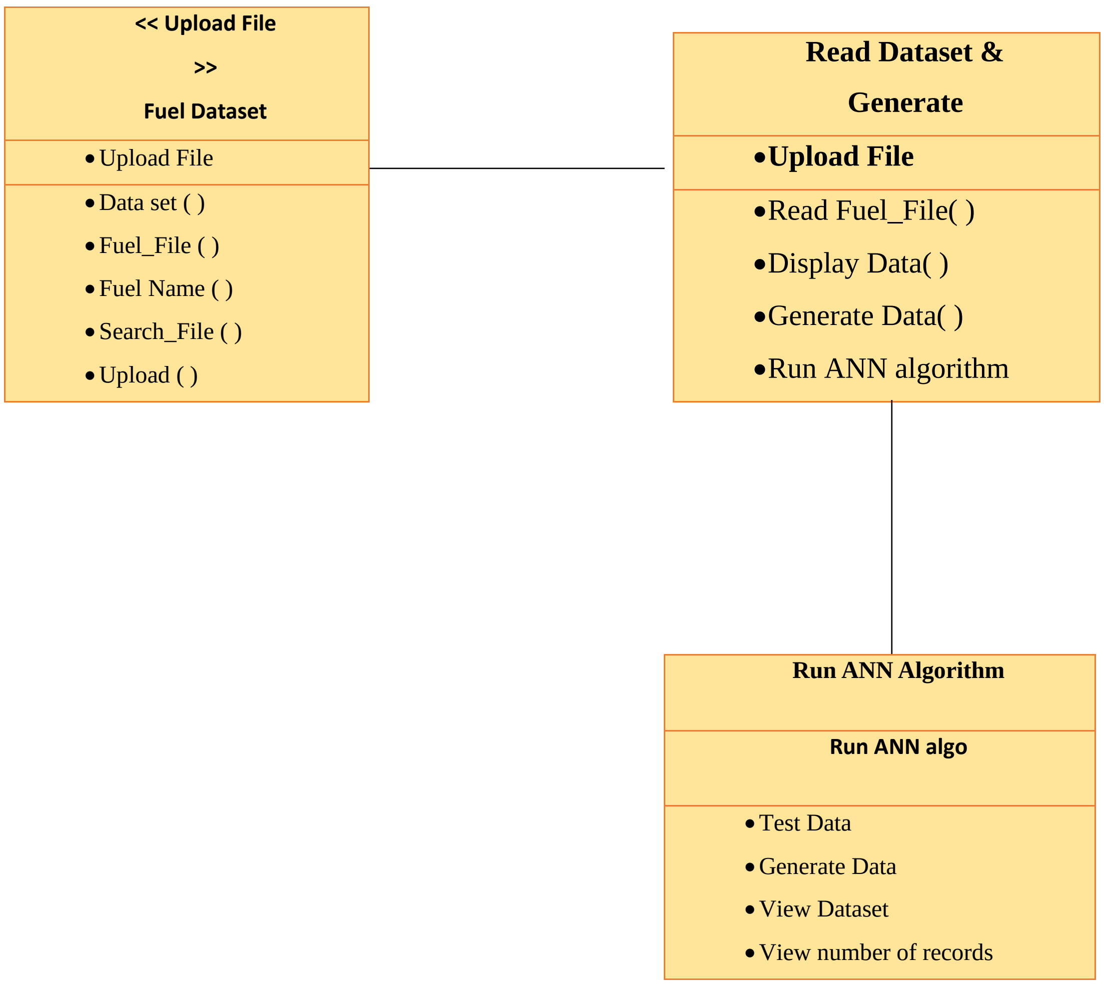


FIGURE 5.2.2 CLASS DIAGRAM

5.2.3 SEQUENCE DIAGRAM:

A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams.

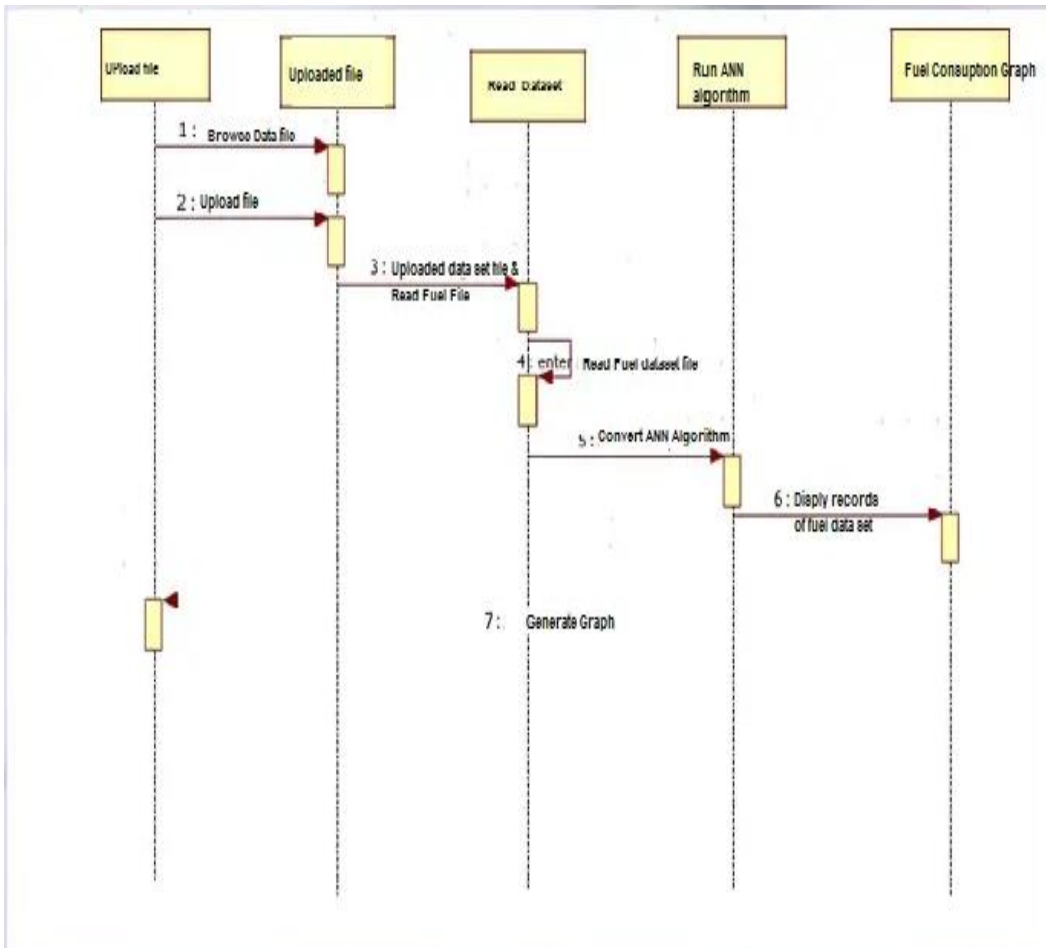


FIGURE 5.2.3 SEQUENCE DIAGRAM

5.2.4 DFD DIAGRAM:

A data flow diagram is graphical tool used to explain and interpret the flow of data through a system.

It is a central tool and the source from which all other elements are developed. The conversion of data from input to output, can be described as physical components associated with the system which is logical and independent. These diagrams are called as the logical data flow diagrams.

The concept behind the discharge of a process into several processes is understanding that at a level of detail is discharged into higher detail at the next level.

This is performed until further discharge is required and a sufficient amount of detail is defined for analyst to know the process.

A DFD is also referred to as the “bubble Chart”, which has a purpose of making clear the system requirements and to identify significant transformations that will be programs in the system design.

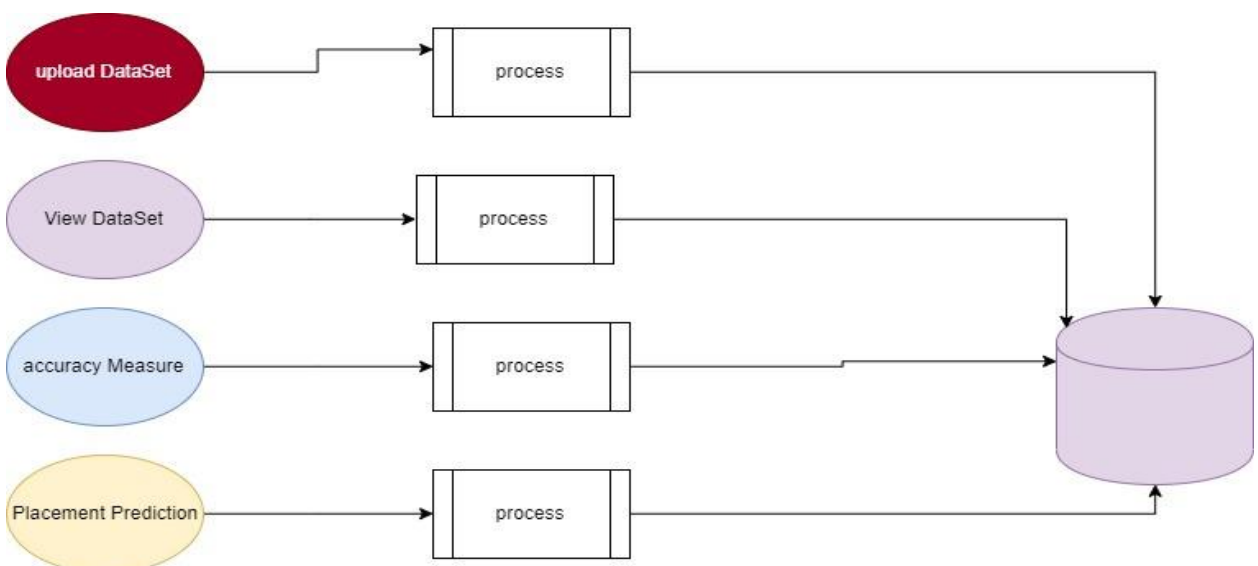


FIGURE5.2.4 DFD DIGRAM

5.2.5 DEPLOYEMENT DIAGRAM:

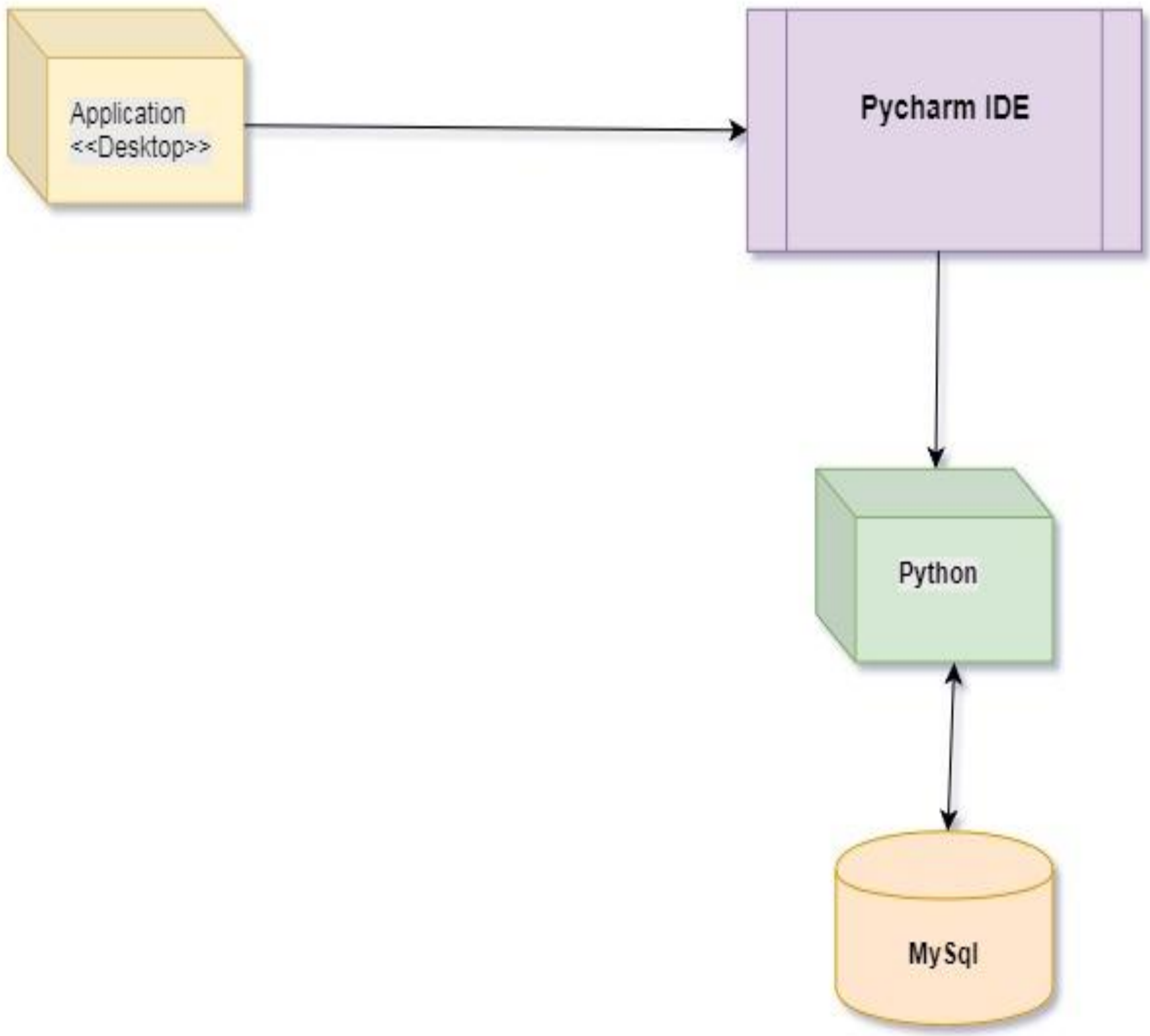


FIGURE 5.2.5 DEPLOYMENT DIGRAM

CHAPTER-6
IMPLEMENTATION

6 SAMPLE CODE

```
from tkinter import messagebox
from tkinter import *
from tkinter import simpledialog
import tkinter
from tkinter import filedialog
import matplotlib.pyplot as plt
import numpy as np
from tkinter.filedialog import askopenfilename
import pandas as pd
from sklearn import *
from sklearn.model_selection import train_test_split
from keras.models import Sequential
from keras.layers.core import Dense,Activation,Dropout
from keras.callbacks import EarlyStopping
from sklearn.preprocessing import OneHotEncoder
from keras.optimizers import Adam
import os

main = tkinter.Tk()
main.title("Average Fuel Consumption")
#designing main screen
main.geometry("1300x1200")

global filename
global train_x, test_x, train_y, test_y
global balance_data
global model
global ann_acc
global testdata
global predictdata

def importdata():
    global balance_data
    balance_data = pd.read_csv(filename)
    balance_data = balance_data.abs()
    return balance_data

def splitdataset(balance_data):
    global train_x, test_x, train_y, test_y
    X = balance_data.values[:, 0:7]
    y_ = balance_data.values[:, 7]
    print(y_)
    y_ = y_.reshape(-1, 1)
```

```
    encoder = OneHotEncoder(sparse=False)
    Y = encoder.fit_transform(y_)
    print(Y)
    train_x, test_x, train_y, test_y = train_test_split(X, Y, test_size=0.2)
    text.insert(END,"Dataset Length : "+str(len(X))+"\n");
    return train_x, test_x, train_y, test_y

def upload(): #function to upload tweeter profile
    global filename
    filename = filedialog.askopenfilename(initialdir="dataset")
    text.delete('1.0', END)
    text.insert(END,filename+" loaded\n\n");

def generateModel():
    global train_x, test_x, train_y, test_y
    data = importdata()
    train_x, test_x, train_y, test_y = splitdataset(data)
    text.insert(END,"Splitted Training Length : "+str(len(train_x))+"\n");
    text.insert(END,"Splitted Test Length : "+str(len(test_x))+"\n");

def ann():
    global model
    global ann_acc
    model = Sequential()
    model.add(Dense(200, input_shape=(7,), activation='relu', name='fc1'))
    model.add(Dense(200, activation='relu', name='fc2'))
    model.add(Dense(19, activation='softmax', name='output'))
    optimizer = Adam(lr=0.001)
    model.compile(optimizer, loss='categorical_crossentropy', metrics=['accuracy'])
    print('CNN Neural Network Model Summary: ')
    print(model.summary())
    model.fit(train_x, train_y, verbose=2, batch_size=5, epochs=200)
    results = model.evaluate(test_x, test_y)
    text.insert(END,"ANN Accuracy for dataset "+filename+"\n");
    text.insert(END,"Accuracy Score : "+str(results[1]*100)+"\n\n")
    ann_acc = results[1] * 100

def predictFuel():
    global testdata
    global predictdata
    text.delete('1.0', END)
    filename = filedialog.askopenfilename(initialdir="dataset")
    testdata = pd.read_csv(filename)
    testdata = testdata.values[:, 0:7]
```

```
    predictdata = model.predict_classes(testdata)
    print(predictdata)
    for i in range(len(testdata)):
        text.insert(END,str(testdata[i])+" Average Fuel Consumption :
"+str(predictdata[i])+"\n");

def graph():
    x = []
    y = []
    for i in range(len(testdata)):
        x.append(i)
        y.append(predictdata[i])
    plt.plot(x, y)
    plt.xlabel('Vehicle ID')
    plt.ylabel('Fuel Consumption/10KM')
    plt.title('Average Fuel Consumption Graph')
    plt.show()

font = ('times', 16, 'bold')
title = Label(main, text=' Average Fuel Consumption in Heavy Vehicles Using Machine
Learning')
title.config(bg='indigo', fg='tan')
title.config(font=font)
title.config(height=3, width=120)
title.place(x=0,y=5)

font1 = ('times', 12, 'bold')
text=Text(main,height=20,width=150)
scroll=Scrollbar(text)
text.configure(yscrollcommand=scroll.set)
text.place(x=50,y=120)
text.config(font=font1)


font1 = ('times', 15, 'bold')
uploadButton = Button(main, text="Upload  Vehicles Fuel Dataset", command=upload)
uploadButton.place(x=50,y=550)
uploadButton.config(font=font1)

modelButton = Button(main, text="Read Dataset & Generate Model",
command=generateModel)
modelButton.place(x=420,y=550)
modelButton.config(font=font1)
```

```
annButton = Button(main, text="Run ANN Algorithm", command=ann)
annButton.place(x=760,y=550)
annButton.config(font=font1)

predictButton = Button(main, text="Predict Average Fuel Consumption",
command=predictFuel)
predictButton.place(x=50,y=600)
predictButton.config(font=font1)

graphButton = Button(main, text="Fuel Consumption Graph", command=graph)
graphButton.place(x=420,y=600)
graphButton.config(font=font1)

exitButton = Button(main, text="Exit", command=exit)
exitButton.place(x=760,y=600)
exitButton.config(font=font1)
main.config(bg='blue')
main.mainloop()
```

CHAPTER-7
TESTING

7. SYSTEM TESTING

Introduction:

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, sub-assemblies, assemblies and/or a finished product It is the process of exercising software with the intent of ensuring that the software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of tests. Each test type addresses a specific testing requirement.

Testing is a debugging process, which is one of the most significant aspects of the triggers in programming. Without a proper working program, the system will never present the desired output. Testing is most beneficial when user development assists in the process of identifying all errors and bugs. A part of the sample data is used for testing, which is called the testing data. It is not quantity but the quality of the data used that matters in the testing. Testing is aimed at guaranteeing that the system is accurate and efficient.

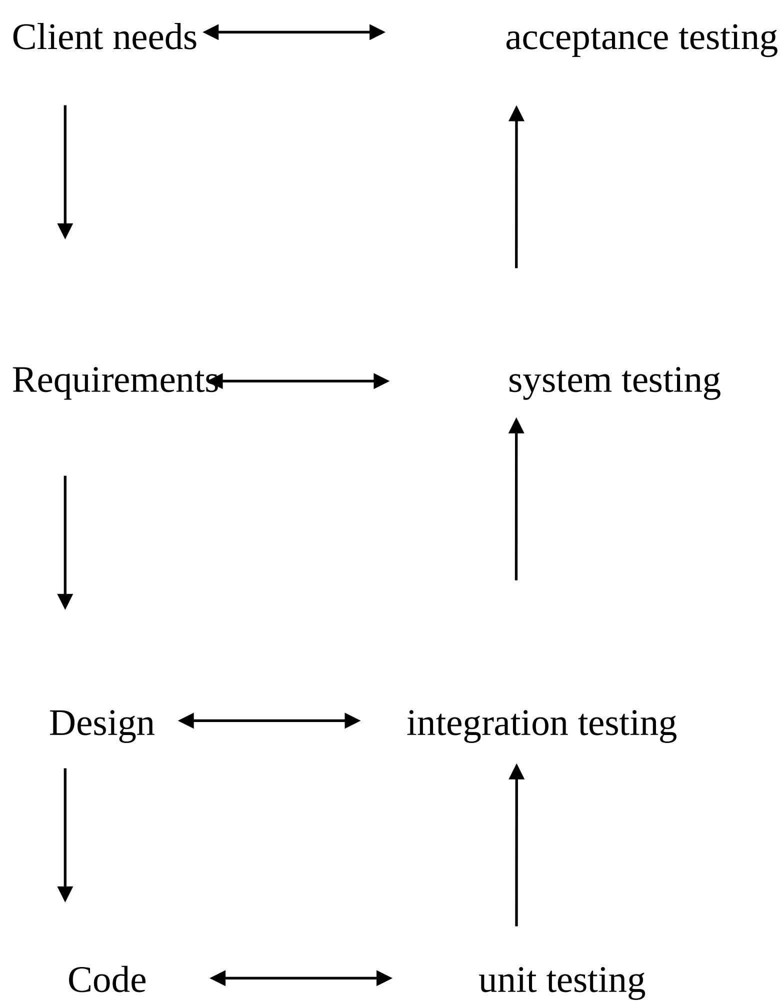
Purpose of Testing

The aim of testing is often to demonstrate that a program works by showing that it has no errors. The basic purpose of testing phase is to detect the errors that may be present in the program. Hence one should not start testing with the intent of showing that a program works, but the intent should be to show that a program doesn’t work. A primary purpose of testing is to detect software failures so that defects may be discovered and corrected. Testing cannot establish that a product functions properly under all conditions, but only that it does not function properly under specific conditions. The scope of software testing may include the examination of code as well as the execution of that code in various environments and conditions as well as examining the aspects of code: does it do what it is supposed to do and do what it needs to do. In the current culture of software development, a testing organization may be separate from the development team. There are various roles for testing team members. Information derived from software testing may be used to correct the process by which software is developed.

Testing Objectives

The main objective of testing is to uncover a host of errors, systematically and with minimum effort and time. To evaluate the work products such as requirements, design, user stories, and code.To verify the fulfillment of all specified requirements.To validate if the test object is complete and works as per the expectation of the users and the stakeholders.

The basic levels of Testing:



Unit Testing

Unit testing refers to tests that verify the functionality of a specific section of code, usually at the function level. In an objectoriented environment, this is usually at the class level, and the minimal unit tests include the constructors and destructors. A Unit is a smallest testable portion of system or application which can be compiled, liked, loaded, and executed. This kind of testing helps to test each module separately.The aim is to test each part of the software by separating it. It checks that component are fulfilling functionalities or not. This kind of testing is performed by developers.

Integration Testing

Integration testing is any type of software testing that seeks to verify the interfaces between components against a software design. Software components may be integrated in an iterative way or all together ("big bang"). Normally the former is considered a better practice since it allows interface issues to be located more quickly and fixed. Integration means combining. For Example, In this testing phase, different software modules are combined and tested as a group to make sure that integrated system is ready for system testing. Integrating testing checks the data flow from one module to other modules. This kind of testing is performed by testers.

System Testing

System testing tests a completely integrated system to verify that the system meets its requirements. System testing is performed on a complete, integrated system. It allows checking system's compliance as per the requirements. It tests the overall interaction of components. It involves load, performance, reliability and security testing. System testing most often the final test to verify that the system meets the specification. It evaluates both functional and non-functional need for the testing.

Acceptance Testing

Acceptance Testing is a test conducted to determine if the requirements of a specification or contract are met. Acceptance testing is a test conducted to find if the requirements of a specification or contract are met as per its delivery. Acceptance testing is basically done by the user or customer. However, other stockholders can be involved in this process.

Each Module can be tested using the following two approaches:

- Black Box Testing
- White Box Testing

Black Box Testing:

Black box testing is a software testing technique in which the functionality of the Software Under Test (SUT) is examined without studying the internal code, implementation details and information of inner paths of the software. This type of testing is done on the basis completely of the software requirements and specifications. In Black Box Testing we just concentrate on inputs and output of the software system without fretting about inner knowledge of the software program.

White Box Testing:

The white box testing is one of two components of the "box testing" approach of software testing. Its counterpart, black box testing, includes testing from an external or end-user type prospect. While Whitebox testing is on the basis of the internal workings of an application and rotates around internal testing. The term "white box" was used because of the see-through box theory. The clear box or white box name signifies the capability to see through the software's outer shell (or "box") into its interior functioning

Importance of Software Testing

Few can argue against the need for quality control when developing software. Late delivery or software defects can damage a brand's reputation — leading to frustrated and lost customers. In extreme cases, a bug or defect can degrade interconnected systems or cause serious malfunctions.

Though testing itself costs money, companies can save millions per year in development and support if they have a good testing technique and QA processes in place. Early software testing uncovers problems before a product goes to market. The sooner development teams receive test feedback, the sooner they can address issues such as:

• Architectural flaws

• Poor design decisions

• Invalid or incorrect functionality

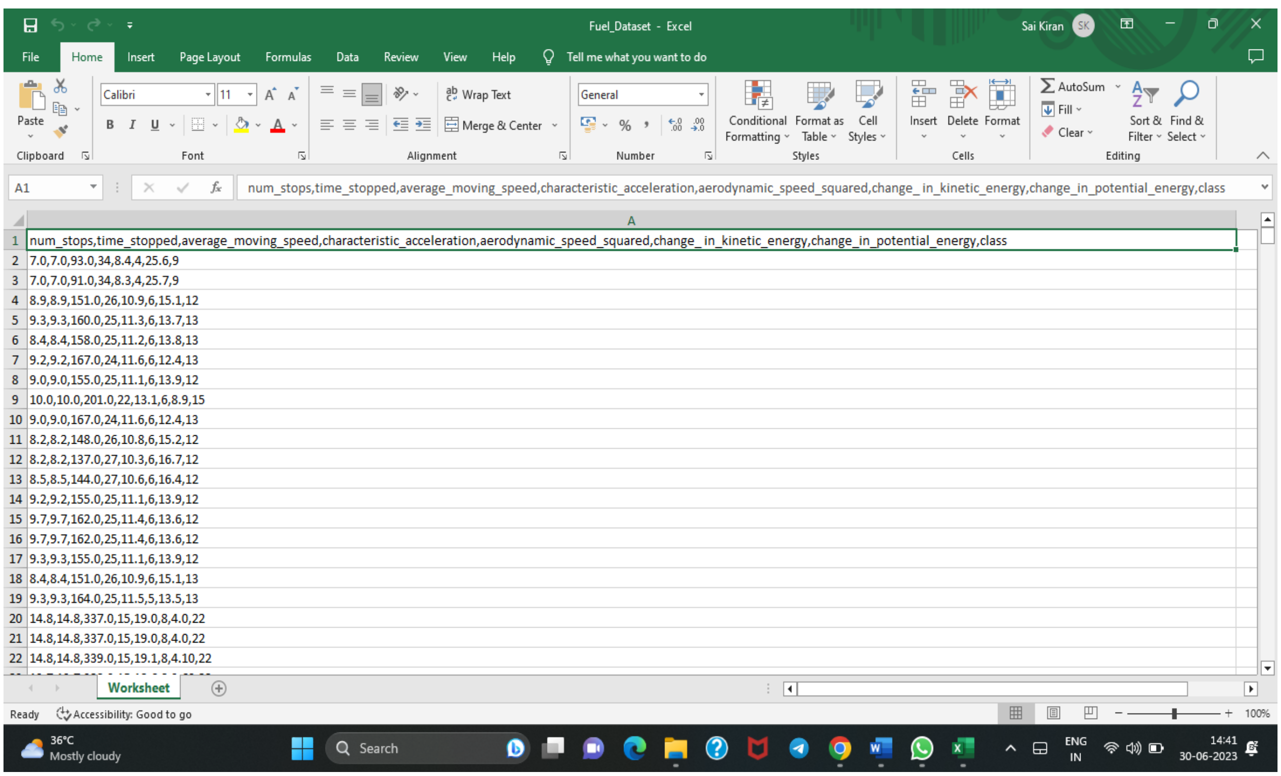
• Security vulnerabilities

• Scalability issues

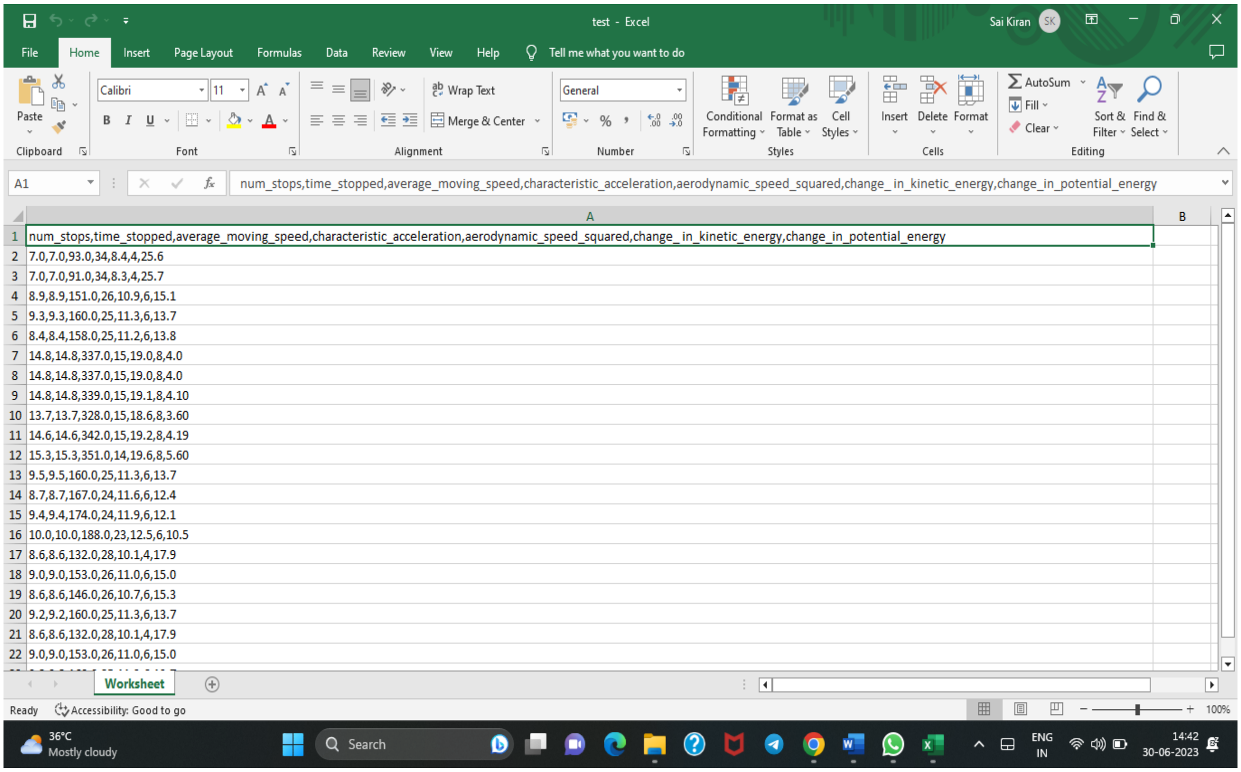
When development leaves ample room for testing, it improves software reliability and high-quality applications are delivered with few errors. A system that meets or even exceeds customer expectations leads to potentially more sales and greater market share.

DATA SETS USED FOR THE PROJECT:

Fuel_Dataset data base:



Train data set:

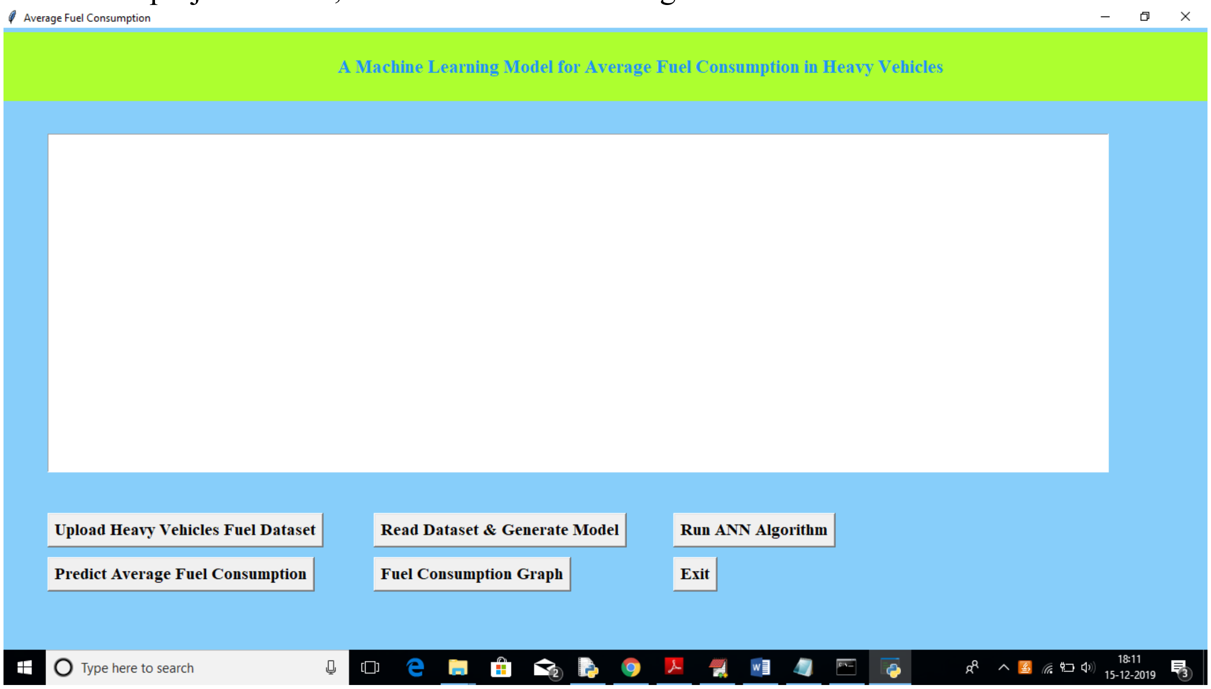


CHAPTER-8
OUTPUT SCREENS

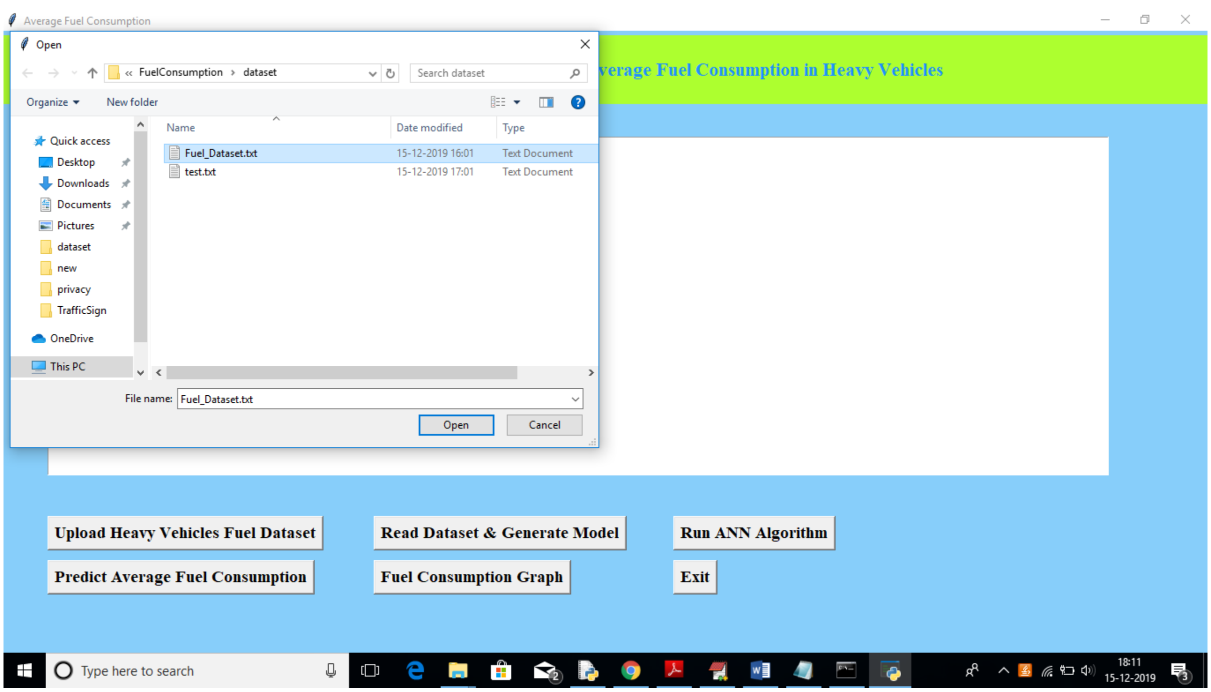
8 SCREEN SHOTS

8.1 Home Page

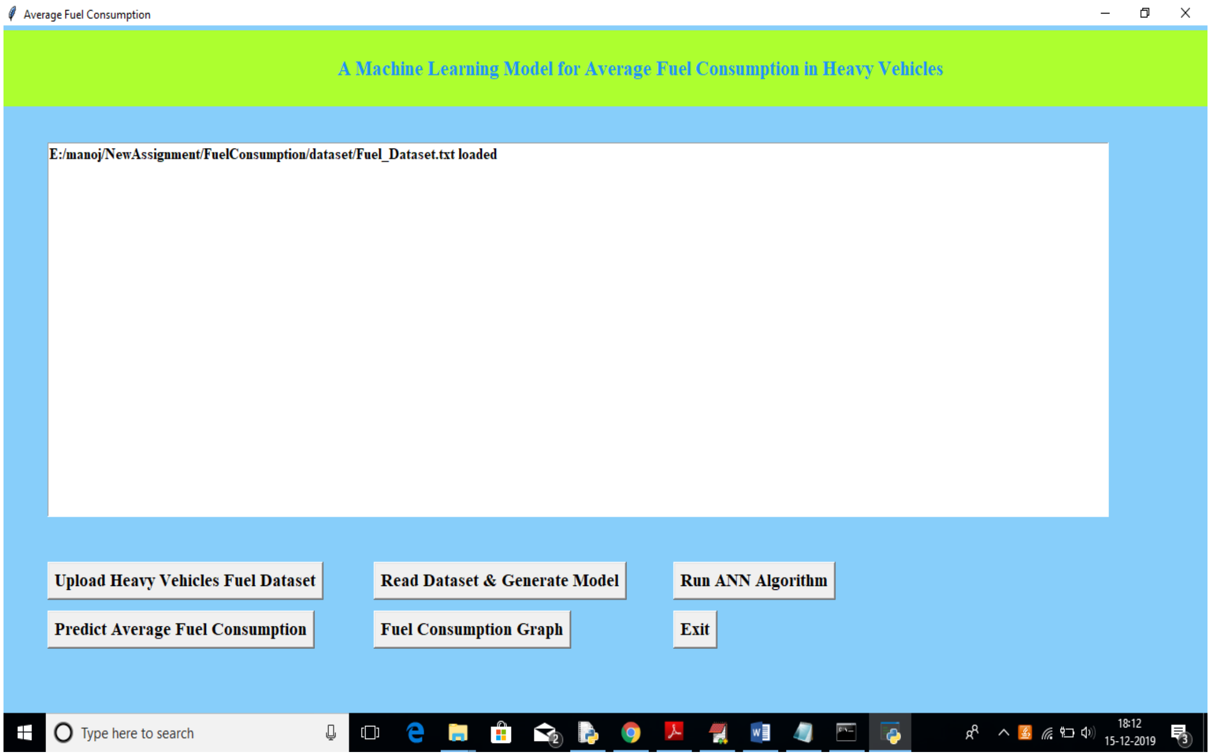
To run this project double, click on ‘run.bat’ file to get below screen



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

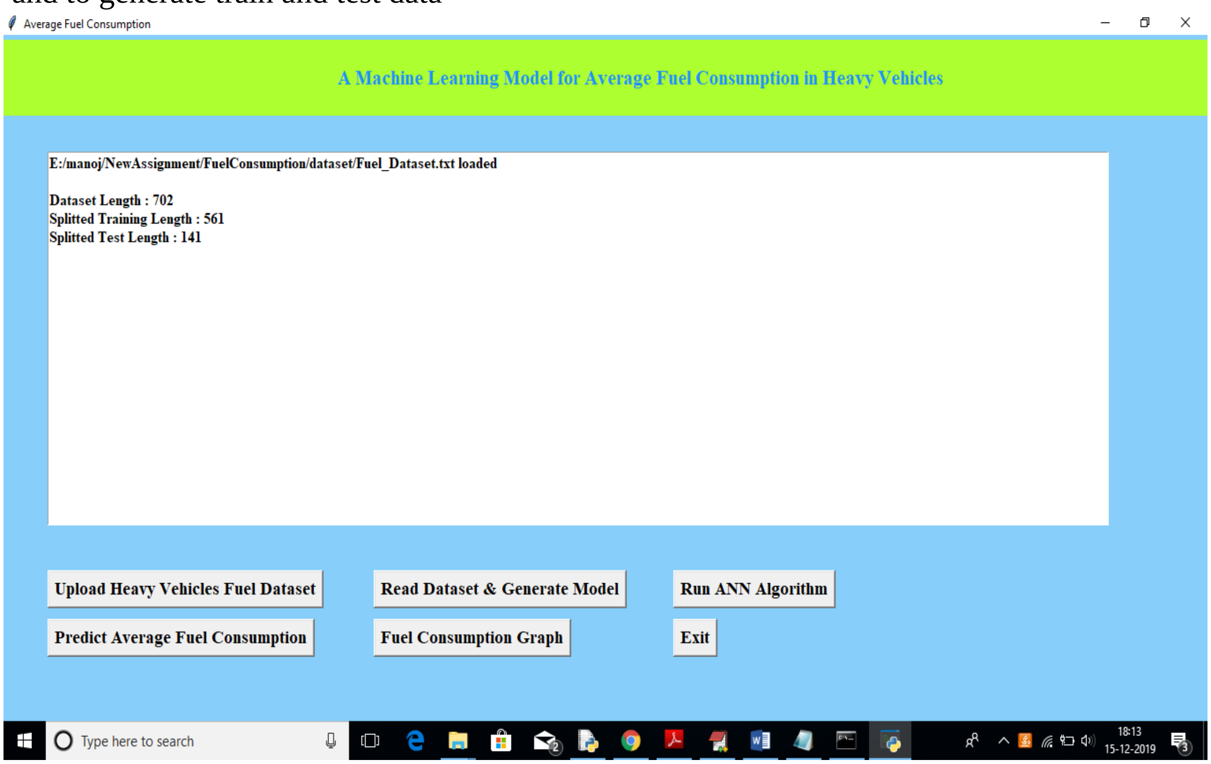


In above screen uploading ‘Fuel_Dataset.txt’ which can be used to train model. After uploading
dataset will get below screen

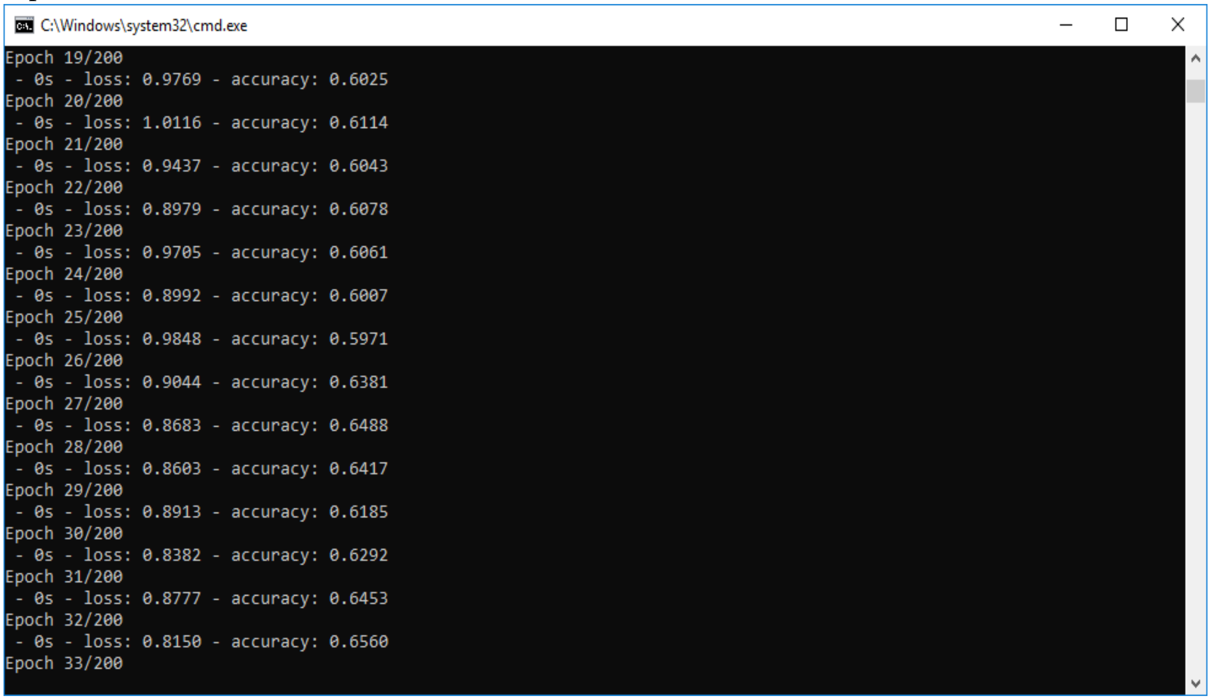


Now in above screen click on 'Read Dataset & Generate Model' button to read uploaded dataset

and to generate train and test data

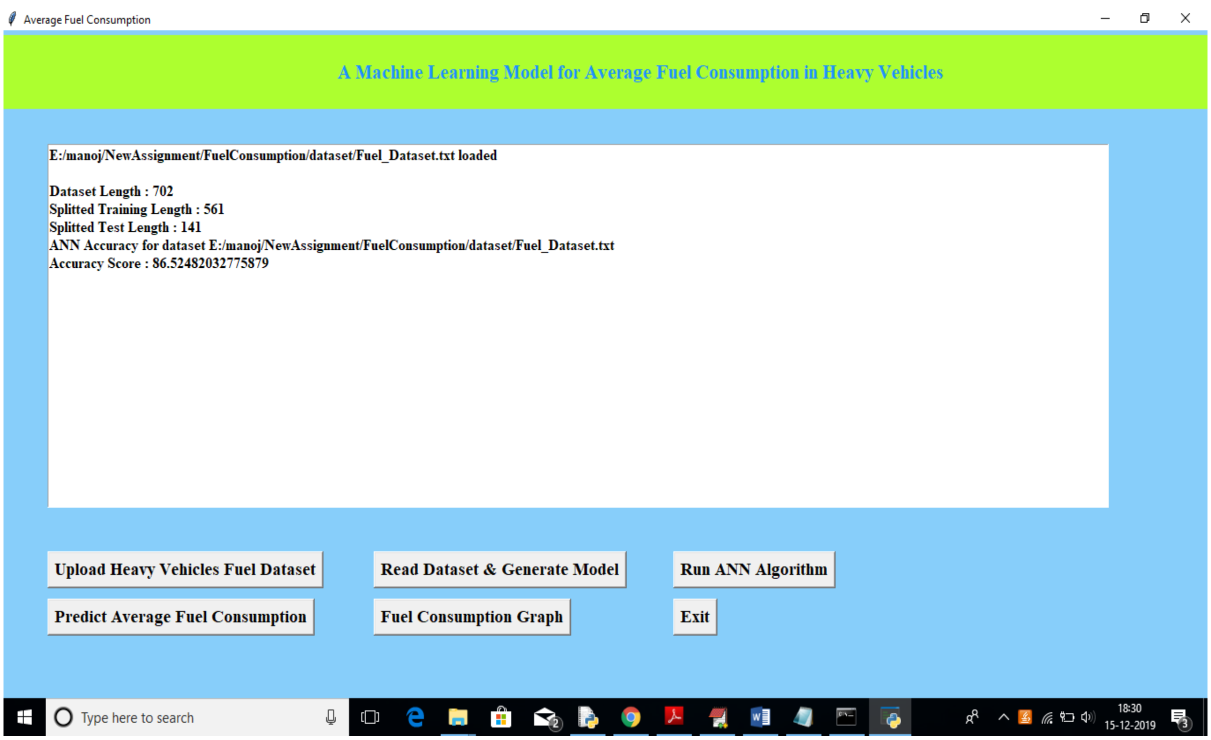


In above screen we can see total number of records in dataset, number of records used for training and number for records used for testing. Now click on 'Run ANN Algorithm' button to input train and test data to ANN to build ANN model.



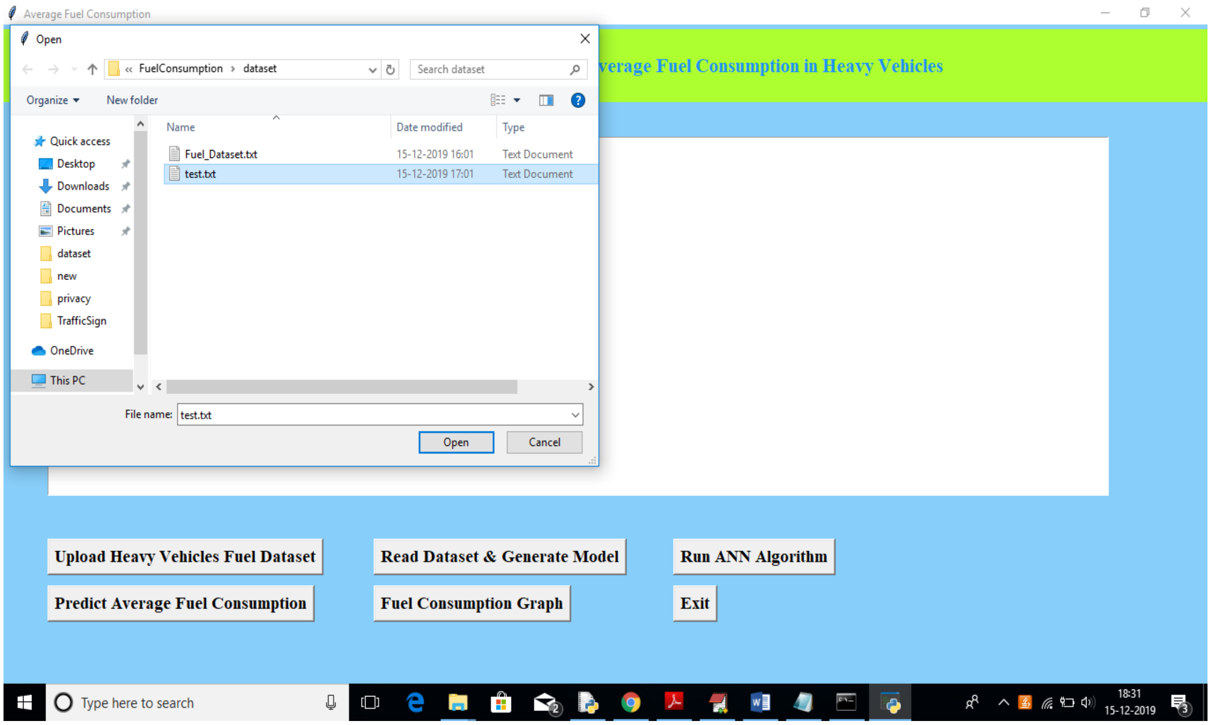
In above black console we can see all ANN processing details, After building model will get below

screen

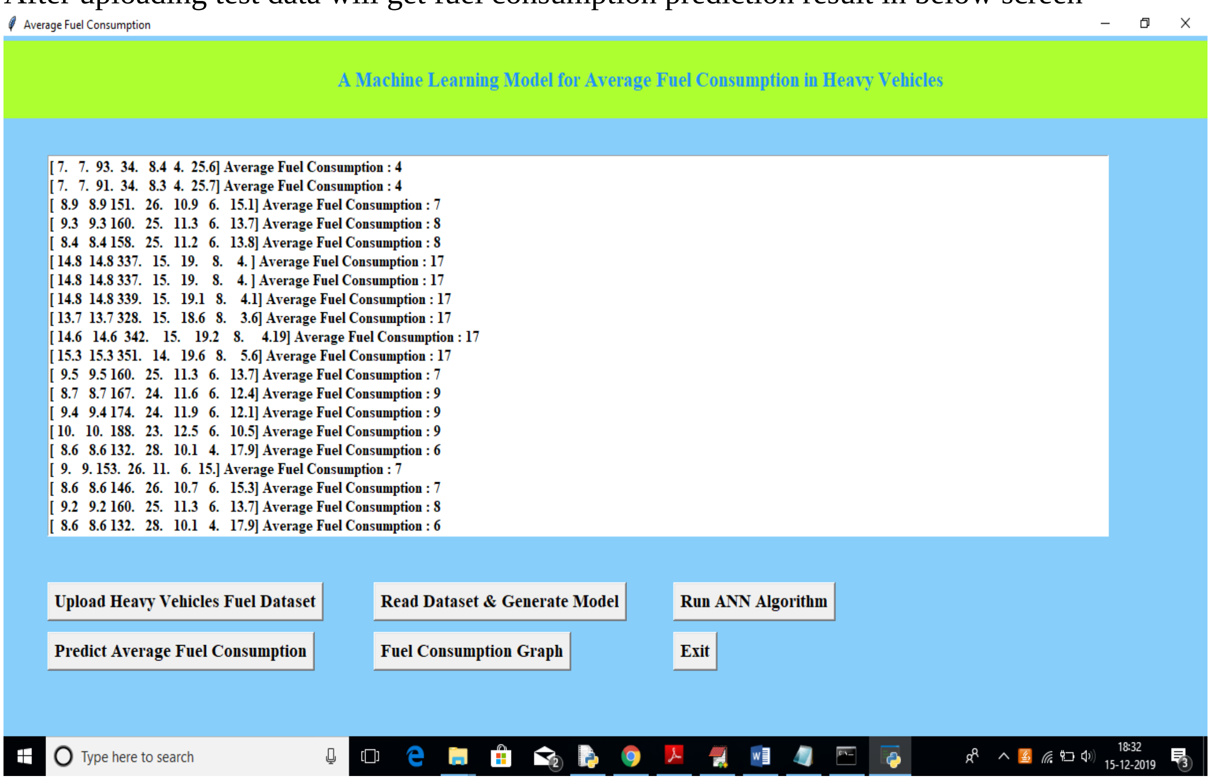


In above screen we got ANN prediction accuracy up to 86%. Now click on 'Predict Average

Fuel Consumption' button to upload test data and to predict consumption for test data

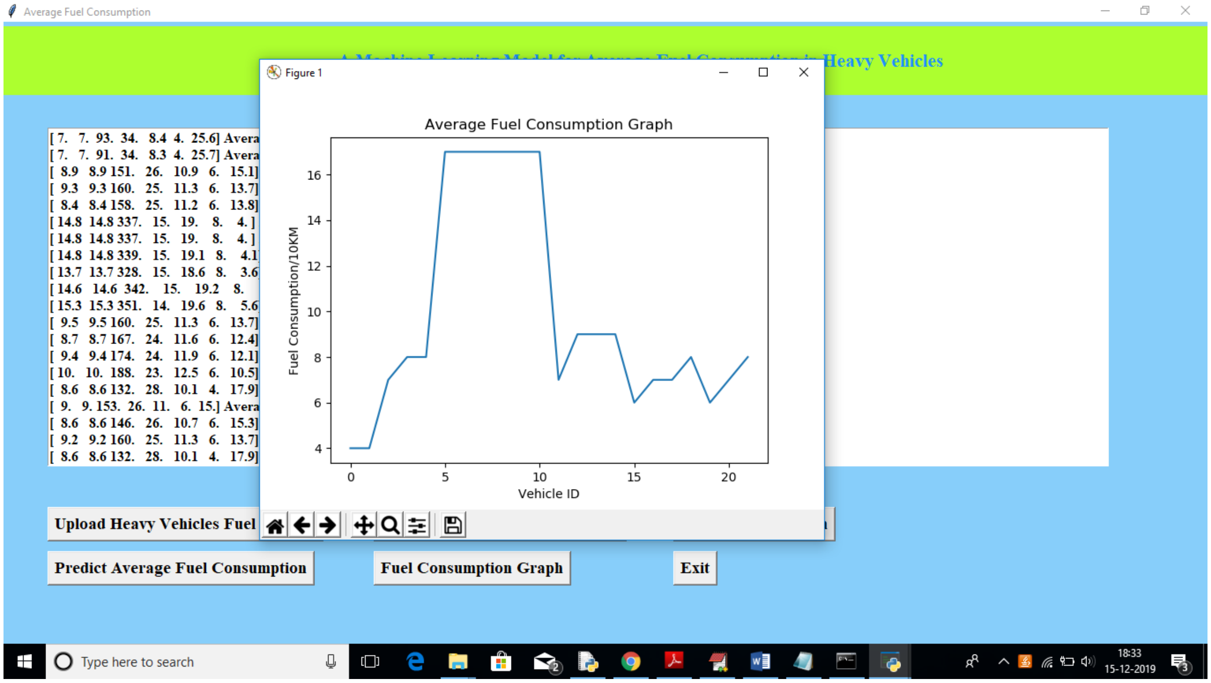


After uploading test data will get fuel consumption prediction result in below screen



In above screen we got average fuel consumption for each test record per 100 kilo meters. 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.

CHAPTER-9
CONCLUSION

9. CONCLUSION

machine learning model that can be helpfully produced for every weighty vehicle in an armada. The model depends on seven indicators: number of stops, stop time, normal moving rate, trademark speed increase, streamlined speed squared, change in active energy and change in possible energy. The last two indicators are acquainted in this paper with assistance catch the typical unique way of behaving of the vehicle. The indicators of the model are all gotten from vehicle speed and street level. These factors are promptly accessible from telematics gadgets that are turning into an indispensable piece of associated vehicles. In addition, the indicators can be handily figured on-board from these two factors

CHAPTER-10
BIBLIOGRAPHY

10. BIBLIOGRAPHY

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missions%2Bbook&ots=dWGsw6mQ0b&sig=DJyCWVZNizZm15jtW5UgOgf3a1A&redir_esc=y#v=onepage&q=co2%20emissions%2Bbook&f=false. Accessed 28 June 2023.

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Average Fuel Consumption in Heavy Vehicles Using Machine Learning

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I. *ABSTRACT*

In this study, we developed customised machine learning models for fuel consumption[1] using vehicle travel distance rather than the conventional time period. Seven predictors generated from vehicle speed and road grade are combined with this method to create a highly predictive neural network model for average fuel consumption in large vehicles. To reduce fuel usage across the board, the suggested methodology can be quickly established and implemented for each individual vehicle in a fleet. The model's predictors are combined over predetermined window sizes for distance travelled. The evaluation of various window sizes reveals that a 1 km window has a 0.91 coefficient of determination and a mean absolute peak-to-peak percent accuracy in predicting fuel usage.

***Keywords*:** Fuel consumption, machine learning, neural network, vehicle travel distance, road grade, fleet optimization, ANN, image classifier, neural network architecture

II. INTRODUCTION

Vehicle manufacturers, regulators, and consumers are all interested in FUEL consumption models. They are required during every stage of the life of the vehicle. The average fuel consumption of heavy trucks during the phase of operation and maintenance is the major topic of this article. Techniques used to create models of fuel use often fall into one of three categories: models based on physics-which come from a thorough comprehension of the physical system. These simulations explain the dynamics of the vehicle's parts. data-driven machine learning[2] models: These models represent an abstract mapping from an input space containing a chosen collection of predictors to an output space that corresponds to the desired output. Additionally, data-driven, statistical models provide a relationship between the probability.

II.A)SYSTEM ANALYSIS

In a total framework examination of a typical fuel utilization project in weighty vehicles utilizing AI, the initial step is to characterize the issue, which is to foresee the typical fuel utilization in light of different elements. Then, information assortment happens, where pertinent information, for example, authentic fuel utilization records, vehicle details, driving circumstances, climate information, and driver conduct is assembled. The gathered information is then preprocessed by dealing with missing qualities, eliminating anomalies, and normalizing or scaling highlights. Highlight choice and designing are performed to distinguish the most applicable elements that effect fuel utilization[3]. The picked calculation for demonstrating and expectation is an Artificial Neural Network (ANN). The information is parted into preparing and testing sets, and the ANN model is prepared utilizing the preparation information. The model's exhibition is assessed utilizing measurements like mean outright mistake or coefficient of assurance. Advancement methods, including hyperparameter tuning and regularization, can be applied to work on the model's presentation. When the model is viewed as good, it very well may be sent in a creation climate, where its expectations are persistently observed and assessed for exactness and unwavering quality.

II.B)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[4] 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

II.C)PROPOSED SYSTEM

Artificial Neural Network (ANN)[5] are frequently used to foster computerized models for complex frameworks. The models proposed in feature a portion of the troubles looked by AI models when the info and result have various spaces. In this review, the information is accumulated in the time area north of 10 minutes stretches and the result is fuel utilization over the distance went during a similar time span. The intricate framework is addressed by an exchange capability F(p) = o, where F(·) addresses the framework, p alludes to the information indicators and o is the reaction of the framework or the result. The ANNs utilized in this paper are Feed Forward Brain Organizations (FNN). Preparing is an iterative cycle and can be performed utilizing different methodologies including molecule swarm enhancement and back proliferation. Different methodologies will be viewed as in future work to assessment their capacity to work on the model's prescient exactness. Every cycle in the preparation chooses a couple of (input, yield) highlights from Ftr aimlessly and refreshes the loads in the organization. This is finished by ascertaining the mistake between the real result esteem and the worth anticipated by the model

II.D)FEASIBLITY STUDY

Feasibility analysis[6] begins once the goals are defined. It starts by generating broad possible solutions, which are possible to give an indication of what the new system should look like. This is where creativity and imagination are used. Analysts must think up new ways of doing things- generate new ideas. There is no need to go into the detailed system operation yet. The solution should provide enough information to make reasonable estimates about project cost and give users an indication of how the new system will fit into the organization. It is important not to exert considerable effort at this stage only to find out that the project is not worthwhile or that there is a need significantly change the original goal. Feasibility of a new system means ensuring that the new system, which we are going to implement, is efficient and affordable. There are various types of feasibility to be determined. They are,

II.D.1)Economically Feasibility

As a portion of this, the expenses and profits related with the implemented systems are to be associated. The project is carefully feasible only if tangible and intangible assistances balance the cost. We can say the implemented system is feasible founded on the following grounds

II.D.2)Technical feasibility

In the technical feasibility study, one has to assess whether the implemented system can be established using existing technology or not. It is intended to implement the implemented system in JSP. The project enabled is theoretically feasible since the following reasons.

1.Recognise the various technologies incorporated within the proposed system: We must be extremely clear on the technologies that will be needed for the creation of the new system before we start the project.

2.Determine if the organisation presently has the necessary technologies: Is the organisation equipped with the necessary technology? In such case, is the capacity adequate? For instance, "Will the new reports and forms needed for the new system be compatible with the present printer?

II.D.3)Operational Feasibility

This project is operationally feasible[15] for there is necessary support from the project organization and the users of the implemented system Implemented system absolutely does not damage and determination not create the corrupt results and no problem will ascend after Search document implementation[7] of the system.

1.User-friendly: Customer will use the forms for their various transactions i.e.. for adding new routes, viewing the routes details. Also, the Customer wants the reports to view the various transactions based on the constraints. These forms and reports are generated as user friendly to the Client.

2.Reliability: The package wills pick-up current transactions on line. Regarding the old transactions, User will enter them in to the system.

3.Security: The web server and database server should be protected from hacking, virus etc.

III.SPECIFICATION

III.A)HARDWARE REQUIREMENTS (Minimum Requirement)

1.RAM:4GB+RAM

2.PROCESSOR: i3 10th Gen 2.2 Ghz

III.B)SOFTWARE REQUIREMENTS

1.Domain: Python

2.Version: Python IDLE (3.11.2)

3.Code Editors: PyCharm

4.Frameworks and Dependencies: tkinter,matplotlib,Keras,numpy,pandas

5.Operating System: Windows 10

IV.CODE EDITORS

IV.A)PyCharm

PyCharm is an integrated development environment[8] (IDE) used In computer programming, specifically for the Python language. It is developed by the Czech company Jet Brains (formerly known as IntelliJ). It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems (VCSes), and

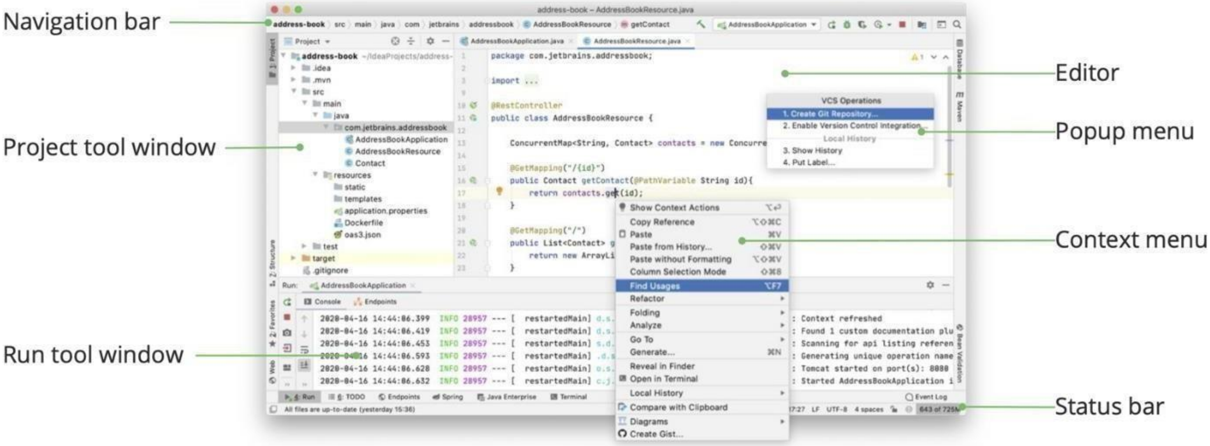

Figure1: PyCharm screen

supports web development with Django as well as data science with Anaconda

•Coding assistance and analysis, with code completion, syntax and error highlighting, linter integration, and quick fixes

•Project and code navigation: specialized project views, file structure views and quick jumping between files, classes, methods and usages

•Python refactoring: includes rename, extract method, introduce variable, introduce constant, pull up, push down and others

•Integrated Python debugger

•Integrated unit testing, with line-by-line code coverage

•Google App Engine Python development

•Version control integration: unified user interface for Mercurial, Git, Subversion, Perforce and CVS with change lists and merge

•Support for scientific tools like matplotlib, numpy and scipy [professional edition only]

PyCharm provide an API so that developers can write their own plugins to extend PyCharm features. Several plugins from other JetBrains IDE also work with PyCharm. There are more than 1000 plugins which are compatible with PyCharm

IV.B)DEVELOPMENT TOOLS AND TECHNOLOGIES:

IV.B.1)PYTHON:

Python is an interpreter, interactive, object-oriented programming language. It incorporates modules, exceptions, dynamic typing, very high-level dynamic data types, and classes. Python combines remarkable power with very clear syntax. It has interfaces to many system calls and libraries, as well as to various window systems, and is extensible in C or C++.

IV.B.2)Python is portable it runs on many Unix variants, on the Mac, and on Windows 2000 and later. When he began implementing Python, Guido van Rossum was also reading the published scripts from "Monty Python's Flying Circus", a BBC comedy series from the 1970s. Van Rossum thought he needed a name that was short, unique, and slightly mysterious, so he decided to call the language Python.

Python is one of those rare languages which can claim to be both simple and powerful. You will find yourself pleasantly surprised to see how easy it is to concentrate on the solution to the problem rather than the syntax and structure of the language you are programming in. Python is simple and minimalistic language. Reading a good Python program feels almost like reading English, although very strict English! This pseudo- code nature of Python is one of its greatest strengths. It allows you to concentrate on the solution to the problem rather than the language itself. Due to its open-source nature, Python has been ported to (i.e., changed to make it work on) many platforms. All your Python programs can work on any of these platforms without requiring any changes at all if you are careful enough to avoid any system-dependent features.

V.RELATED WORK

V.A)Machine learning for fuel consumption prediction in fleet cars Comparative analysis

A vehicle's fuel consumption is influenced by both internal variables like distance, load, vehicle attributes, and driver behaviour, as well as external elements like weather, traffic, and road conditions. It's possible that not all of these variables can be monitored or are accessible for the fuel usage study. When just a portion of the aforementioned characteristics are accessible as a multivariate time series from a long-distance public bus, this is the situation we are going to be looking at. Since only accessible data can be used to estimate and/or anticipate fuel usage, the issue is to capture as much of the indirect effects of other internal and external elements as possible. Improving vehicle fuel economy and combating fraud in fleet management[9] require the ability to model and anticipate fuel usage. As a result, the difficulty is to model and/or estimate fuel usage using only the data that is now accessible while also inadvertently accounting for as many impacts from both internal and external sources. Machine learning (ML) is appropriate in this study since the model may be created by discovering patterns in the data. In this study, given all the relevant parameters as a time series, we assess the prediction performance of three ML approaches in estimating the fuel consumption of the bus.

V.B)fuel consumption modelling for heavy and medium-duty vehicles based on driving cycle characteristics

Data gathered from chassis testing on a parcel delivery diesel truck operating over the Heavy Heavy-Duty Diesel Truck (HHDDT)[10], City Suburban Heavy Vehicle Cycle (CSHVC), New York Composite Cycle (NYCC), and hydraulic hybrid vehicle (HHV) drive cycles were used to develop and verify a polynomial model, a black box artificial neural net model, a polynomial neural network model, and a multivariate adaptive regression splines (MARS) model. Because HHDDT incorporates a range of drive parameters, including high speed, acceleration, idling, and deceleration, it produced the greatest predicted results. MARS provided the greatest prediction performance of the four model methods, with an average percent error of 1.84% throughout the four chassis dynamometer driving cycles. The methods were used on actual data in order to assess the prediction models' accuracy further. The average percent error for MARS across four actual road segments was 2.2%, outperforming the other three techniques.

V.C)European experimental monitoring of co2 emissions from HDV demonstration of the proposed methodological strategy

In contrast to passenger cars and light commercial vehicles[11], which are monitored using chassis dyno measurements, it was determined that the core of the proposed methodology should be based on a combination of component testing and vehicle simulation. This is because the HDV market is diverse and has unique characteristics. Realistic fuel consumption results and precise simulation of the operation of various vehicle components are prioritised. A new legal framework for tracking and disclosing CO2 emissions[12] from Heavy Duty Vehicles (HDVs) in Europe is being developed by the European Commission in collaboration with Heavy Duty Vehicle manufacturers, the Graz University of Technology, and other consulting and research organisations. A number of tests were performed on 2 distinct trucks: a DAF 18 tonne Euro V rigid truck and a Daimler 40 tonne Euro VI long haul delivery truck with semi-trailer. Both on-road and in the HDV chassis dyno laboratories of the Joint Research Centre, measurements were made. The measurements' results were used to validate a car simulator (car Energy Consumption Calculation Tool, or VECTO), which was created to be utilised for official monitoring reasons.

VI.MODULE DESCRIPTION

There are five modules in this project.

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 module, 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. In above test data class value as fuel consumption is not there and when we applied this test record on ANN model then ANN will predict fuel consumption class value for that test record. Entire train and test data available inside 'dataset' folder

VII.DATACOLLECTION AND SUMMARIZATION

A single vehicle with an estimated mass of 8,700kg that was exposed to a variety of drifters, including motorway and urban traffic in the Indianapolis area, was used to collect obligation cycles for the model. The SAE J1939 standard for sequential control and correspondences in rock solid vehicle organisations[13] was used to gather information. Twelve drivers were asked to demonstrate either good or bad behaviour throughout two different courses. Drivers who behaved properly were supposed to slow down and, when it was safe to do so, let the car drift. The distribution of drivers and courses across the informative collection isn't consistent since some drivers participated more than others. The vehicle's CAN transport generated 3, 302, 890 interesting data points for this field test, which had an overall distance of 778.89 km and 56 excursions with varying distances. The majority of the journey was between 10 and 15 km long. Engineered obligation cycles spanning a long distance were obtained by gathering bits from the randomly selected field obligation cycles in order to increase the quantity of data of interest.

VII.A)Model Predictors:

The model's indications needed to be produced through a few handling phases. Street level and gearbox yield speed[14] are two estimations from which these indications are obtained. The initial handling stage included a street level inspection and determining the vehicle speed from the yield speed of the gearbox. An on-board inclinometer was used to measure street level, and it was down-inspected to 1 Hz. A review of the data also revealed a clear correlation between the vehicle speed and the gearbox yield speed indicated by the accompanying condition: Vehicle Speed ≈ 59.3 × Transmission Result Speed

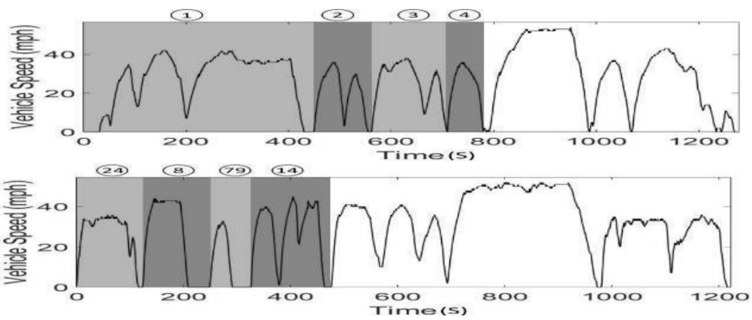

Figure2.The first four segments of a sample real duty cycle (top). A sample synthetic duty cycle created by concatenating segments 24, 8, 79, and 14 from the real data (bottom)

TABLE I

NUMBER OF DATA POINTS (I.E., WINDOWS) AND TOTAL DISTANCE FOR THE TRAINING (F(x)tr) AND THE TESTING (F(x)ts) DATA SETS WITH VARYING SIZE WINDOWS (I.E., 1, 2, AND 5 km.)

Window size	F(x)tr		F(x)ts	
	Number of Points	Distance (km)	Number of Points	Distance (km)
x = 1 km	20,000	20,000	32,089	32,089
x = 2 km	20,000	40,000	23,106	46,212
x = 5 km	20,000	100,000	6,061	30,305

The top predictors were chosen because it is considered that they accurately reflect vehicle dynamics, driver behaviour, and the route's effect on the model's intended output (i.e., fuel consumption). Particularly, a prior study claims that mechanical speed and characteristic acceleration are highly predictive of the fuel consumption for a specific duty cycle. This study contends that the inertia works necessary to accelerate the vehicle is closely related to characteristic acceleration[16], and the mechanics speed square accurately depicts the effect of aeromechanics on fuel consumption.

VII.B)MODEL OUTPUT

The average amount of gasoline consumed over all of the journeys varies, according to a study of the segments in the real data gathered from the field. For instance, throughout the course of whole excursions, a 20% difference in fuel use was found between excellent and bad driving behaviour. Additionally, differences in typical fuel usage are seen for various window widths. The model's output is the average fuel consumption in litres per 100 km for each window. Fuel prices are taken from the will bus in order to calculate the average use. Discontinuities in the fuel rate are found from one phase to the next because false duty cycles are formed from a random selection of genuine duty cycle segments[17], as in the case of road grade. Because gasoline prices are averaged throughout the whole window to determine the output of the model (i.e., average fuel usage), the effects of these discontinuities are not significant. In conclusion, the proposed model's input characteristics are all obtained using the aforementioned methods from the vehicle speed and the road grade samples taken at a rate of 1 Hz. A telematics device can provide these variables.

TABLE II

PREDICTIVE ACCURACY OF THE FUEL CONSUMPTION MODELS FOR 1, 2 AND 5 km AGGREGATION WINDOWS.

Window	1 km	2 km	**5 km**
CD	0.91 (0.0066)	0.87 (0.0085)	0.79 (0.0136)
RMSE (l/100km)	0.0132 (0.0005)	0.0142 (0.0005)	0.0234 (0.0008)
MAE (l/100km)	1.88 (0.0626)	1.69 (0.0515)	1.43 (0.0466)
MAPEpk	3.74% (0.12%)	4.20% (0.13%)	5.83% (0.19%)
Points	32,089	23,106	6,061

Table II demonstrates that, for all measures, the 1 km model outperforms the other two window widths. These performance measures assess the model's performance point-by-point, as was already described. In particular, the 1 km model's coefficient of determination (CD)[19] is equal to 0.91, demonstrating that the model can monitor real fuel use for each 1 km of travel. The CD gets smaller as the window gets bigger. High precision fuel sensors are used, yet the suggested model still outperforms them in terms of MAE and CD. The models' RMSE is likewise smaller than 0.025 l/100 km, which is better than the outcomes. Nevertheless, this paper's test distance is greater.

The performance measures shown in Table II appear to illustrate that the proposed models use highly predictive input characteristics that are appropriately transferred to the model's output space. The AIW values of the predictors are calculated and compiled in Table III to help understand the impact of each one.

VII.C)MODEL VALIDATION

The neural network model receives its input from the seven predictors that are given in Section IV. The network's bottom layer is made up of this. Next, a hidden layer with 5 neurons receives input from the first layer. The hidden layer then transmits information to an output player made up of only one neuron. Figure 3 displays the RMSE over the course of training for three models with 1, 2, and 5 km window widths. Each data point in the top panel corresponds to the RMSE[18] values after the model was trained using a set of 500 windows. According to this graphic, all models converge to an RMSE value of less than 0.2 l/100 km. The convergence rates for the models vary, though. In actuality, the 5 km's RMSE value drops to 0.08 l/100km as the model converges from its initial value of 0.16 l/100km after 500 training windows. For the 1 km model, the comparable values are 0.34 and 0.14 litres per 100 km, respectively.

TABLE III

ADJUSTED INFLUENCE OF WEIGHTS (AIW) FOR THE PREDICTORS IN THE PROPOSEDMODEL

Window	**1 *km***	**2 *km***	**5 *km***
No. of Stops	1.49	2.29	4.63 3.44
Stop Time	0.62	1.24	8.98
Avg. Moving	13.73	10.78	12.98
Speed a ˜ $v2$ $aero$	12.47	14.32	10.30
CKE CPE	11.73	11.64	12.26
Bias	17.04	16.13	9.38
	13.73	11.45	38.03
	29.21	32.15	

As the window size rises, the number of stops and the stop duration become more crucial. This is predicted given that there are less stops visible in the 1 km view than in the 2 or 5 km windows. Across all window sizes, the remaining predictors all show strong AIW. In actuality, models with any of these indicators removed had reduced prediction accuracy. Additionally, Table III shows that the two novel predictors included in this study had an equivalent impact on predicting fuel consumption to average moving speed, characteristic acceleration, and aerodynamic speed.

VIII.SYSTEM IMPLEMENTATION

Data collection and preprocessing, feature selection and engineering, model selection and training, model evaluation, model optimisation, deployment, and ongoing monitoring and maintenance comprise the overall machine learning implementation of the average fuel consumption project for heavy vehicles.

1.Data Gathering and Preprocessing: Gathering pertinent data and putting it together by dealing with outliers, missing numbers, and normalisation.

2.Feature Selection/Engineering: Choosing or developing the key elements that have the most influence on fuel consumption.

3.Model Selection and Training: Using the data that has been gathered and processed, selecting a suitable machine learning model, such as an Artificial Neural Network (ANN), and training it.

4.Model assessment: Using the right assessment metrics and testing data, determine how well the trained model performed.

5.Model Optimisation: Using methods like hyperparameter tuning[20], regularisation, or sophisticated model architectures, the model is fine-tuned.

6.Deployment: Including the improved model in a system or production environment to estimate actual fuel use.

7.Monitoring and Maintenance: Constantly keeping an eye on the performance of the deployed model, spotting concept drift, and to provide precise and trustworthy predictions, the model may need to be updated or retrained.

VIII.A)PURPOSE

The goal of the average fuel consumption project for heavy vehicles using machine learning is to create a predictive model that precisely predicts the fuel consumption of heavy vehicles based on different variables like vehicle specifications, driving circumstances[21], weather data, and driver behaviour. The project seeks to give insights and tools that can assist optimise fuel economy[23], save operating costs, and make wise decisions regarding fuel usage in heavy truck operations by utilising machine learning techniques.

VIII.B)SYSTEM MAINTENANCE

Several crucial tasks are involved in system maintenance for the project employing machine learning to estimate average fuel usage in heavy vehicles:

1.Data gathering: Compile pertinent information, such as past fuel consumption statistics, vehicle specs, road conditions, weather information, and driver behaviour.

2.Data preprocessing: To guarantee data quality and consistency, tidy the obtained data by managing missing values, eliminating outliers, and normalising or scaling features.

3.Data Updates: To include new information and preserve data accuracy, the model's data, such as fuel consumption records and other pertinent data sources, should be updated on a regular basis.

4.Feature Selection/Engineering: From the preprocessed data, choose or engineer the elements that have the greatest influence on fuel usage, taking into account things like vehicle specs, road conditions, weather information, and driver behaviour.

5.Data Monitoring: Continually check the accuracy and integrity of the data to make sure the input data is trustworthy and up-to-date. to maintain precise forecasts of fuel usage.

6.Data Drift Detection: Keep an eye out for changes in the underlying data distribution over time, also known as idea drift. Implement strategies for detecting and controlling drift, such as keeping an eye on feature distributions and assessing the effects they have on forecasts of fuel use.

7.Data Storage and Accessibility: Ensure that the data is safely kept and made available to the machine learning system in order to provide effective training, assessment, and future upgrades.

The system can produce accurate and trustworthy projections[22] of the typical fuel consumption of heavy trucks by efficiently handling the data throughout the project lifetime, from collection and preprocessing through updates and monitoring.

IX.CONCLUSION

machine learning model that may be created to be beneficial for each heavy vehicle in an armada. The seven indications that make up the model are: the number of stops, the stop duration, the average moving rate, the growth in trademark speed, the squared streamlined speed, the change in active energy, and the change in potential energy[24]. The final two signs are discussed in this essay to help readers identify the normal and distinctive ways that each vehicle behaves. All of the model's indications are derived from street level and vehicle speed. Telematics devices, which are fast becoming an essential component of linked automobiles, may quickly access these parameters. Additionally, these two elements make it easy to figure out the signs.

IX.A)SCOPE FOR FUTURE DEVELOPMENT

The average fuel consumption project for heavy trucks utilising machine learning has the potential to lead to a number of developments in the future. These include investigating more sophisticated prediction models, such as ensemble approaches or deep learning architectures, to improve the precision and dependability of forecasts[25] of fuel use. Sensors and telematics data may be used to provide real-time monitoring, providing quick feedback and fuel efficiency analyses. To proactively detect maintenance needs and optimise fuel use, predictive maintenance capabilities can be implemented. The project's scope can also be expanded by incorporating advanced analytics techniques, predictive analytics for maintenance and fuel cost estimation, environmental impact analysis, and optimal route planning algorithms that take fuel consumption into account. These are the areas where the project focuses. may help heavy vehicle operations become more cost-effective, more environmentally friendly, and capable of making well-informed decisions.

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Ijji Saikiran studying her 2nd year, Master of Computer Applications in Sanketika Vidya Parishad Engineering College, affiliated to Andhra University, accredited by NAAC. With her interest in machine learning method and as a part of academic project, he used Average Fuel Consumption in Heavy Vehicles using machine learning algorithm by the Artificial Neural Network. As a result of a desire to comprehend the flaws in conventional reporting and to preserve timely and high-quality report output in Fuel Consumption Graph. A completely developed project along with code has been submitted for Andhra University as an Academic Project. In completion of her MCA.

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