A MACHINE LEARNING MODEL FOR AVERAGE FUEL CONSUMPTION IN HEAVY VEHICLES

Internship Report submitted in partial fulfillment of the requirement for the award of the degree of

BACHELOR OF TECHNOLOGY

in

CSE – CYBER SECURITY

By

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GEETHANJALI COLLEGE OF ENGINEERING AND TECHNOLOGY

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(Affiliated to Jawaharlal Nehru Technological University, Hyderabad, Accredited by NAAC and NBA, New Delhi)

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Department of CSE (CS)

CERTIFICATE

This is to certify that the internship report titled A Machine Learning Model for Average Fuel Consumption in Heavy Vehicles being submitted by Samudrala Sai Kiran, bearing roll number 20R11A6251, in partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in CSE (CS) from Jawaharlal Nehru Technological University, Hyderabad during the year 2021-2022.

Examiner	HOD-EA
Name:	Dr.Neeraja
Designation:	Professor

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DECLARATION BY THE CANDIDATE

I, Samudrala Sai Kiran, bearing Roll No. 20R11A6251, hereby declare that the Internship Report entitled **"**A Machine Learning Model for Average Fuel Consumption in Heavy Vehicles **"** is submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Computer Science and Engineering (Cyber Security).

This is a record of bonafide work carried out by me in Cantilever and the results embodied in this internship have not been reproduced or copied from any source. The results embodied in this Internship Report have not been submitted to any other University or Institute for the award of any other degree or diploma.

Samudrala Sai Kiran, 20R11A6251,
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Cheeryal.

ACKNOWLEDGEMENT

I Samudrala Sai Kiran (20R11A6251) would like to thank Cantilever for giving me the opportunity to do an internship within the organization. I also would like to thank all the people who worked along with me with their patience and openness. It is indeed with a great sense of pleasure and immense sense of gratitude that I acknowledge the help of these individuals.

I am highly indebted to Principal, Dr. Udaya Kumar Susarla, for the facilities provided to accomplish this internship. I would like to thank Head of the Department, Dr.K.Neeraja, for her constructive criticism throughout my internship.

CERTIFICATE ACHIEVEMENT/ INTERNSHIP

INTRODUCTION ABOUT COMPANY

Cantilever brings academia & industry very close for a common goal of talent creation through experiential learning & development environment. The platform enables students to move in a successful career path to reach the expectations of industry. They are building the Next-Gen Talent pool with skills in emerging technologies i.e., Artificial Intelligence, Data Science, Internet of Things(lot), Robotics, Blockchain, Quantum Computing and Cyber Security. The unique method of Cantilever is project-based learning, micro-skilling and Internships helps students in building their competency & get ready for industry. They bring students, educators and employers on a common platform to fill the gap between academia & industry.

Methodology: Collaborative learning in a project environment with industry interaction & mentoring.

Learn: Project based learning environment to understand the practical application of theoretical concepts by deeply engaging the students.

Practice: Practice through problem solving and project building can make a student an expert in his field of interest.

Intern: Collaborative working environment with industry mentorship to make young talent ready for real world challenges.

Main objectives of Cantilever:

- Well directed career guidance programs for educational institutions.
- Appropriate certification courses that suit the industry need.
- Train the trainers; expanded awareness about the current industry standards.
- Liaise with corporates to offer niche internships.

One formula they follow for success is 70:20:10 Rule:

- 10% Learn It Yourself: They got the largest library of in demand technologies with the best materials for you to choose when & if you need.
- 20% You Share, You Grow: The platform is designed to skill you up while you work with teams and experts as there are mentors from around the world.
- 70 % Say Hello to experience: There is nothing better than Project based learning and they provide the best of the real-life working experience to you from the comfort practicing anywhere.

The below are some steps about the student's internship program:

STEP-1:

Learn:

Stop Searching Start Learning:

Before we get started with all the future actions, it's important to know what is your favourite subjects.

So, then take first step with the below training modules:

- Largest Selection of In-Demand Programs.
- Broken Micro-objectives nuggets.
- Warm-up to industry's latest tools & techniques.

STEP-2:

Practice:

From Seed to Scale:

With Professional Tools and Procedures getting you best of real time experience with the following:

- 2000+ Real-time Projects Templates.
- Learn to collaborate and work in a professional virtual environment.
- Get Mentored by Industry Experts and Learn tricks of the trade.
- Apply & Work with Enterprise Stack.

STEP-3:

Intern:

Happiness is bringing you closer to become who are meant to be:

An intern is a trainee who has signed on with different organizations for a brief period. To gain work experience, occasionally some university credit, and always an overall feel for the industry they're interning in. Internships may be paid, partially paid, or unpaid.

TRAINING SCHEDULE

Session	Module Title	Topics	Date
1, 2	amming	1. Python Basics 2. Python Data Structures	23-07-22
3,4	OOPs Concepts	1. Classes and objects 2. Exceptions 3. File Handling	27-07-22
5,6,7	Python Modules	1. Numpy 2. Scipy 3. Pandas	06-08-22
8	Intro to Data Science	1. What is data science? 2. Tools for data science 3. Data science methodology	08-08-22
8	Intro to Data Science	1. What is data science? 2. Tools for data science 3. Data science methodology	15-08-22

9,10	Data Analysis withPython	1. Importing data sets 2. Data Wrangling 3. Exploratory data analysis	22-08-22
11	Data Visualization Tools	1. Matplotlib, Scatterplot	29-08-22
12,13,14	Introduction to Machinelearning	1. Types of Machine learning 2. Regression	02-09-22
15,16,17, 18,19	Machine learning withpython	1. Classification 2. Clustering 3. Recommender Systems 4. Project Guidance	06-09-22

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1. ABSTRACT

1.1 Overview

As part of GCET Internship program management for students, I got an opportunity to work on **"A Machine Learning Model for Average Fuel Consumption in Heavy Vehicles"**, a miniscule project , which provides an ability for end users to get an idea about fuel consumption in their vehicles.

1.2 Purpose

Cantilever group collaborated with GCET to envision an approach and provide students an opportunity to understand latest technologies and trends. Developing project would help students to understand current market requirements and enhance their abilities to design and deliver such solutions in future.

1.3 Existing problem

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 litres per kilometre. However, these models are not able to identify and learn trends in average fuel consumption with an adequate level of accuracy.

1.4 Proposed solution

In the proposed model, all the predictors are aggregated with respect to a fixed window that represents the distance travelled 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).

Using the same scale for both the input and output spaces of the model offers several benefits:

1. Data is collected at a rate that is proportional to its impact on the outcome. When the input space

is sampled with respect to time, the amount of data collected from a vehicle at a stop is the same as the amount of data collected when the vehicle is moving.

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

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

2. RELATED WORK/TECHNOLOGIES USED

2.1 Hardware / Software designing

Hardware and software requirements of the project:

Thanks to AWS services and Docker containerization, the hardware and software specifications required to develop and use the application are minimal. Here are the baseline hardware requirements:

- Operating System: Windows 8 onwards, MacOS High Sierra onwards
- Processor Type: Intel core i3 9^{th} gen/ Intel core i5 7^{th} gen/ Intel core i7 5^{th} gen onwards
- Processor Speed: 2 GHZ
- Memory: 250 mb and above

2.2 List of technologies used to create the project

1. Amazon Web Services
2. Docker Virtualization
3. Python Flask Framewor

3. WORK DONE / OBSERVATIONS / DUTIES PERFORMED

Modules of A Machine Learning Model for Average Fuel Consumption in Heavy Vehicles:

1) DATA COLLECTION AND SUMMARIZATION

The module is developed by using duty cycles 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 for serial control and communications in heavy duty vehicle networks .Twelve drivers were asked to exhibit good or bad behaviour over two different routes. Drivers exhibiting good behaviour anticipated braking and allowed the vehicle to coast when possible.

This field test generated 3, 302, 890 data points sampled at 50 Hz from the vehicle CAN bus and a total distance of 778.89 km over 56 trips with varying distances.

2) Artificial Neural Networks (ANN)

Artificial Neural Networks (ANN) are often used to develop digital models for complex systems. The complex system is represented by a transfer

The ANNs used in this project are Feed Forward Neural Networks (FNN). As opposed to linear models (e.g., linear regression), FNNs are capable of representing the nonlinear characteristics of a complex system through the use of a nonlinear activation function

Training is an iterative process and can be performed using multiple approaches including particle swarm optimization and back propagation.

The selected predictors consist of:

Number of stops,

Time stopped,

Average moving speed,

Characteristic acceleration,

Aerodynamic speed squared,

Change in kinetic energy and

Change in potential energy.

The above predictors were selected because they are believed to capture the vehicle dynamics as well as the driver's behaviour and the impact of the route on the target output of the model (i.e., fuel consumption) .This is done by calculating the error between the actual output value and the value predicted by the model.

3) MODEL VALIDATION

The training process is followed by a validation process that is used to measure the performance of the model, the accuracy of the model is evaluated by using the mean absolute error (MAE).

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.

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 consider 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.

4. LIST OF FIGURES AND SCREENS

1 - Diagrammatic overview of Use-Cases

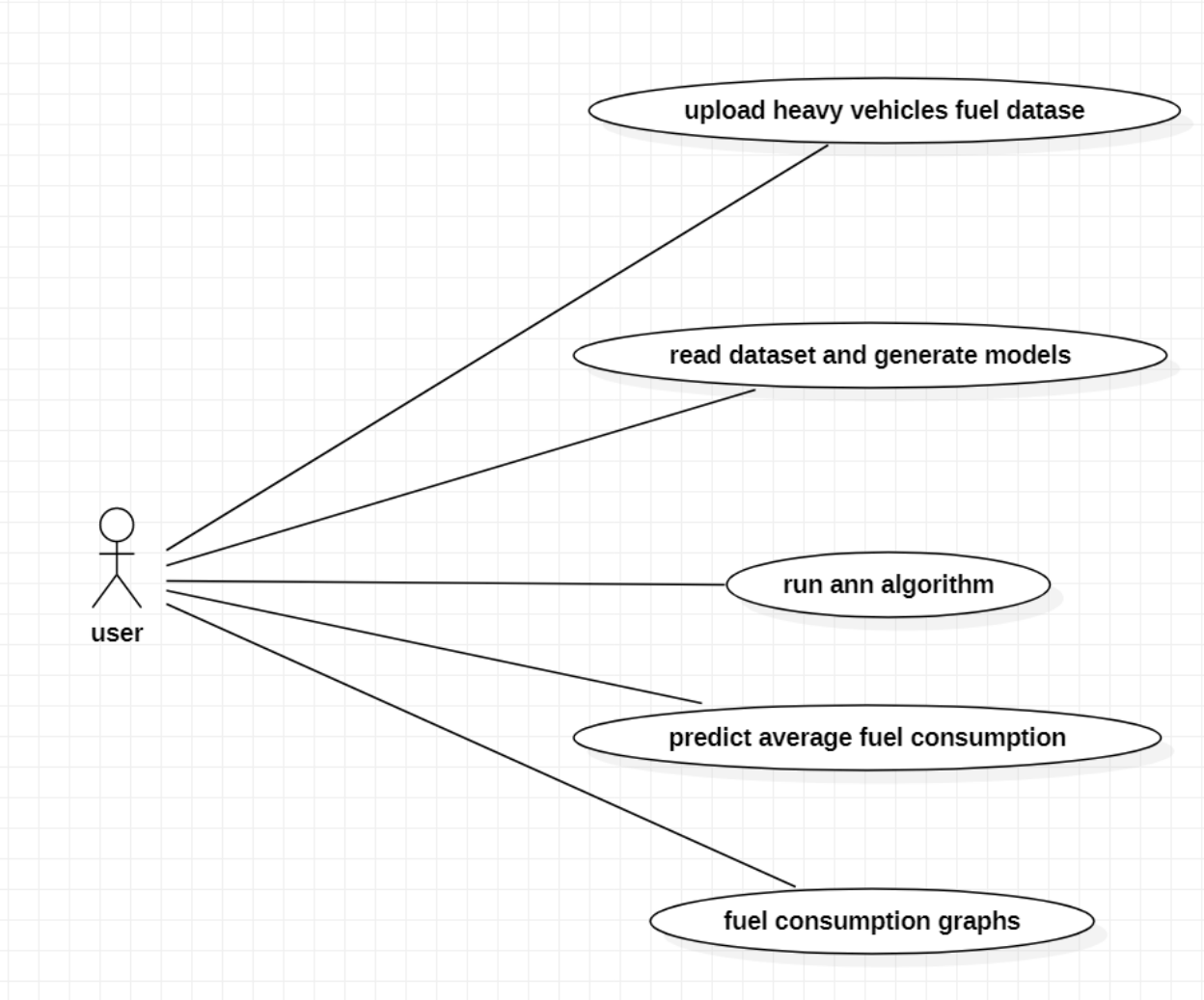


Fig: Use Case Diagram

2 - Diagram showing the control flow of the solution

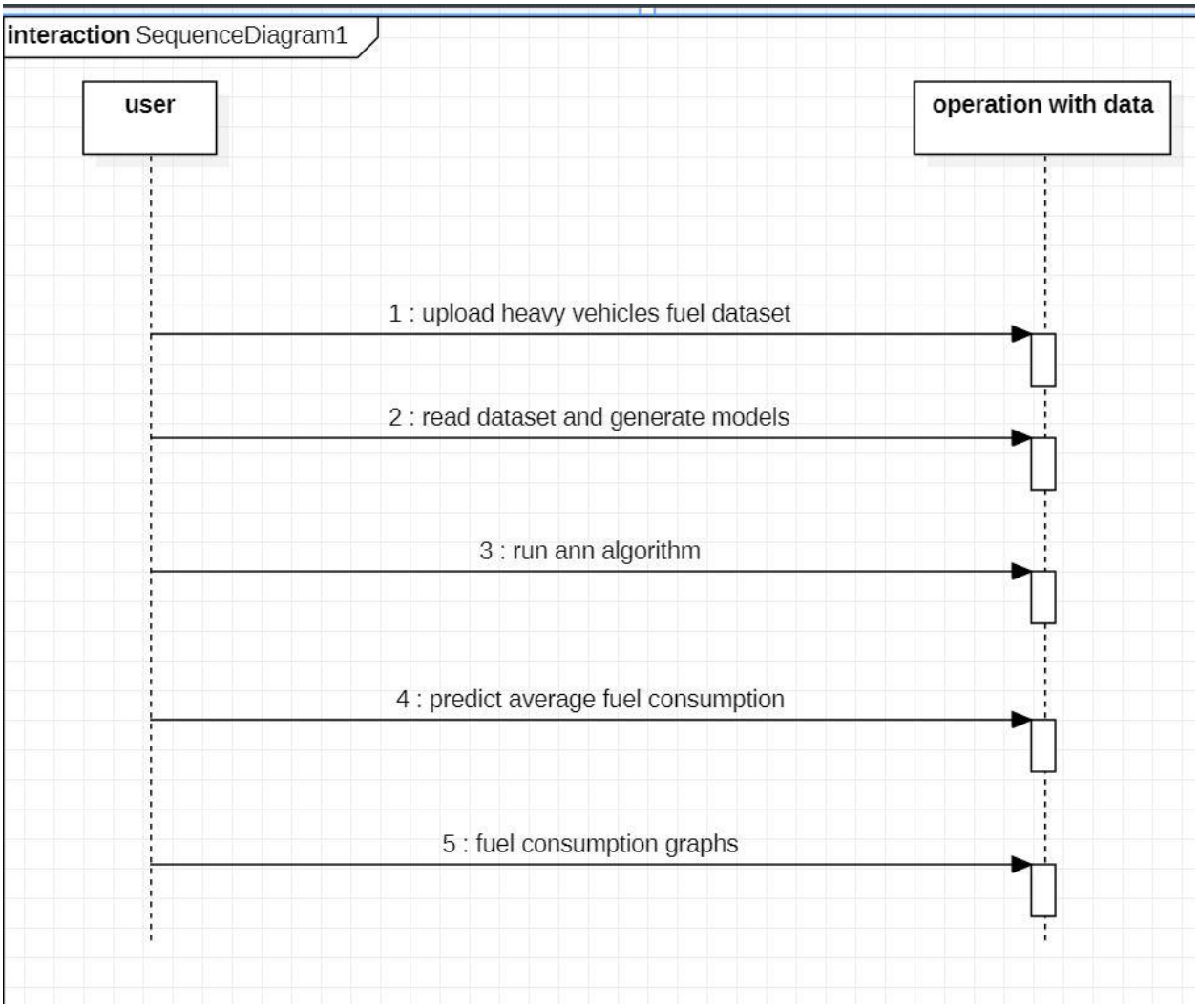


Fig: Sequence Diagram

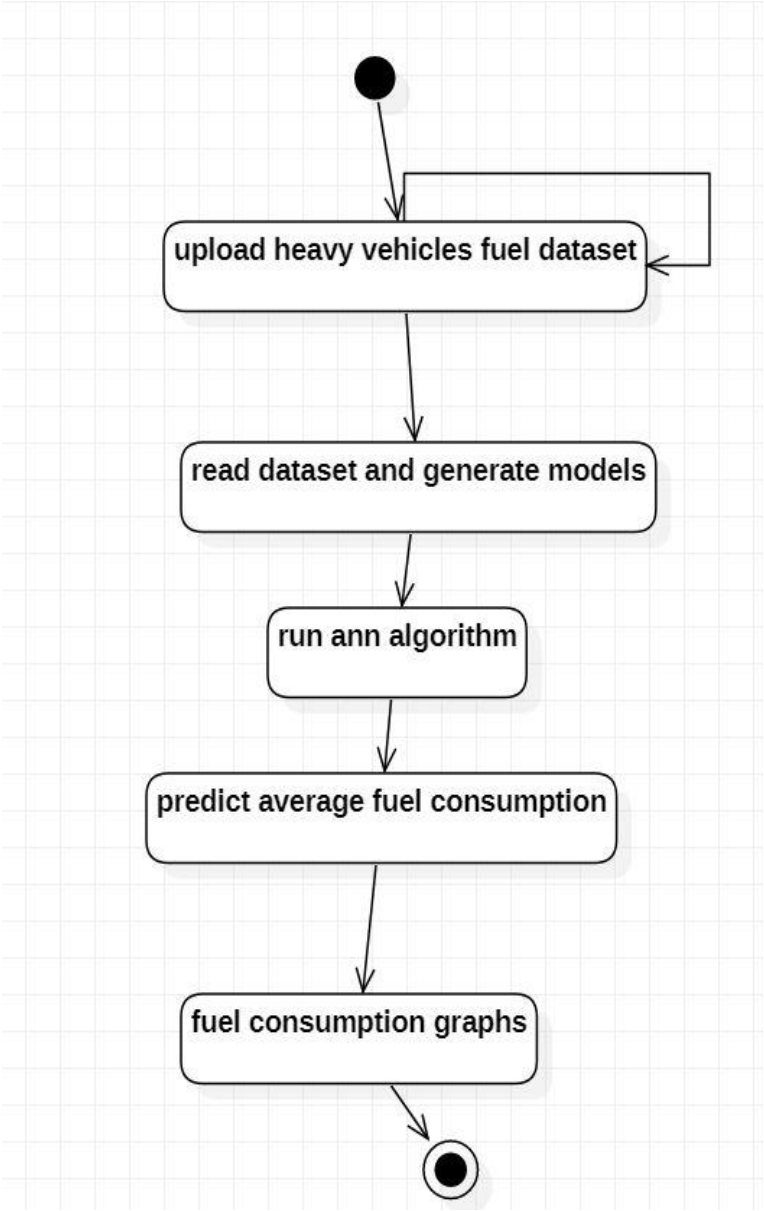


Fig: State chart Diagram

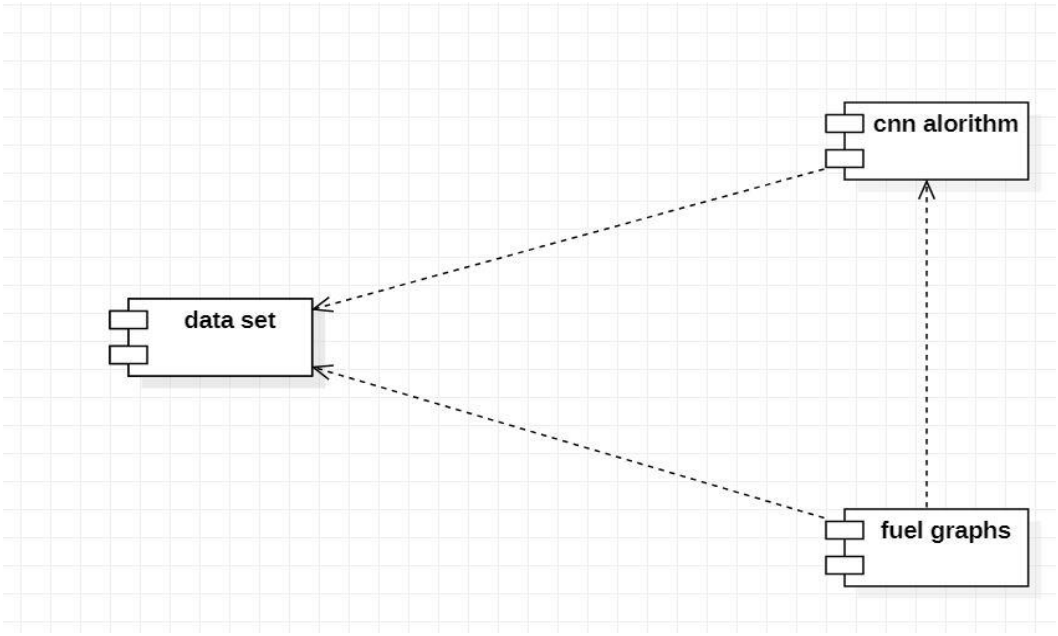


Fig: Component Diagram

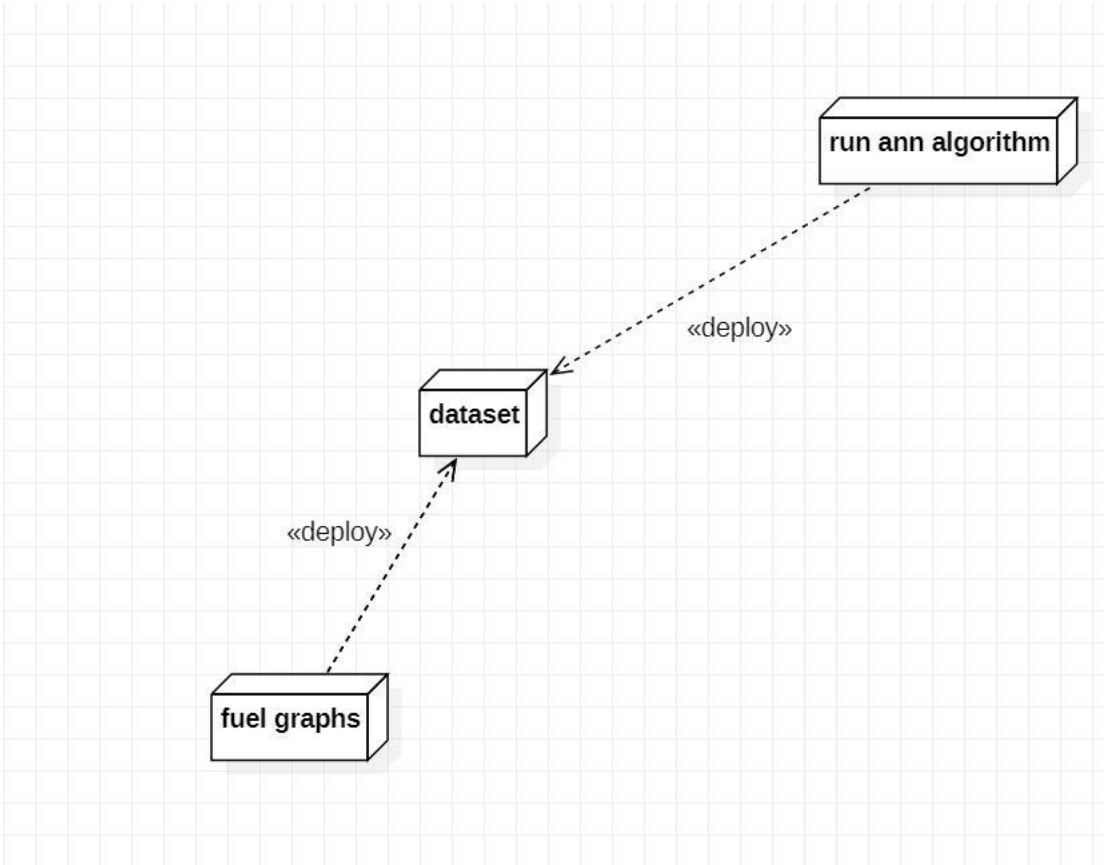


Fig: Deployment Diagram

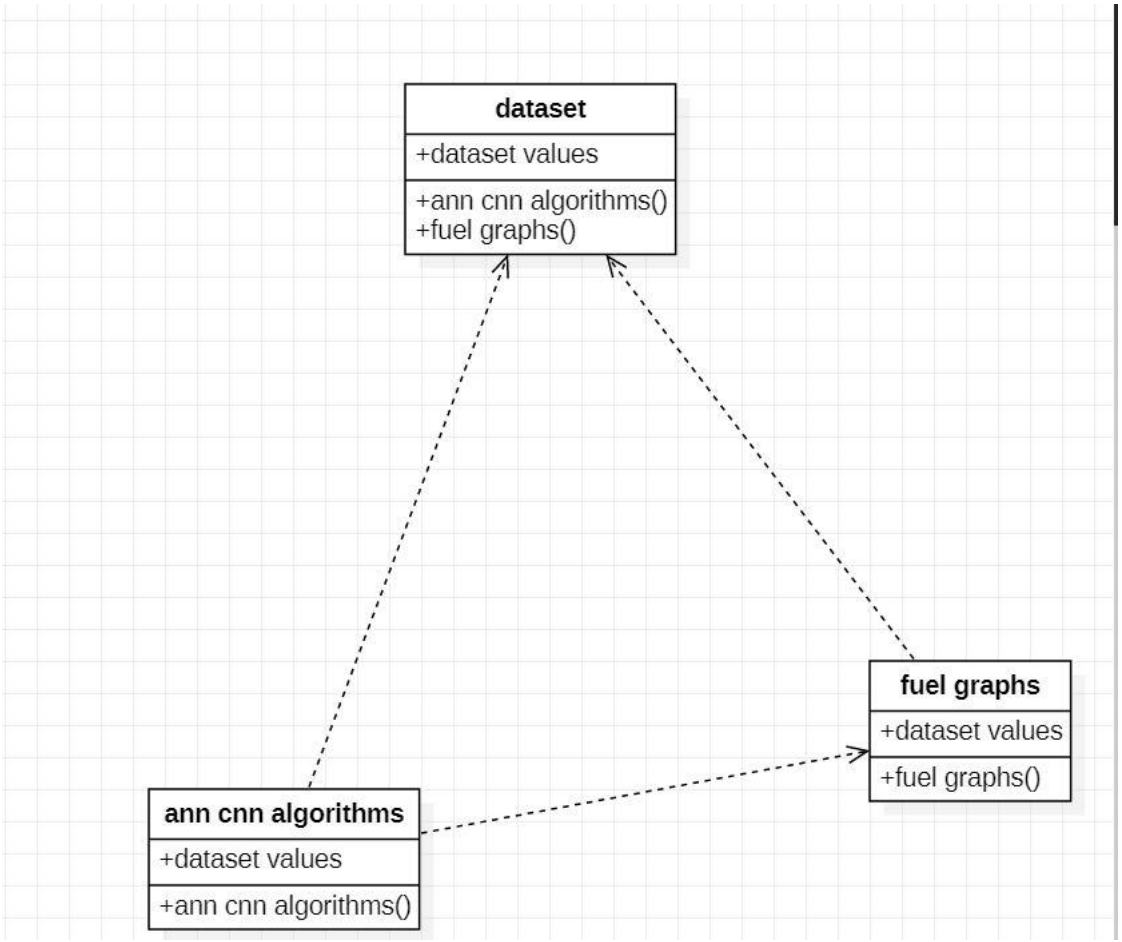
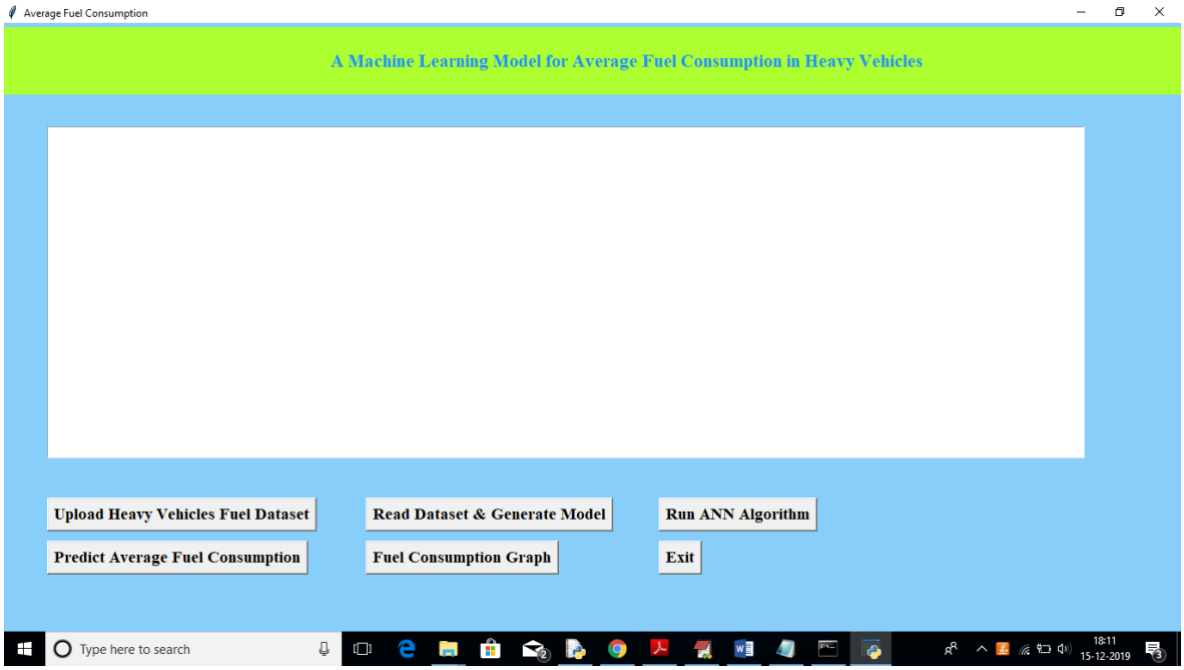


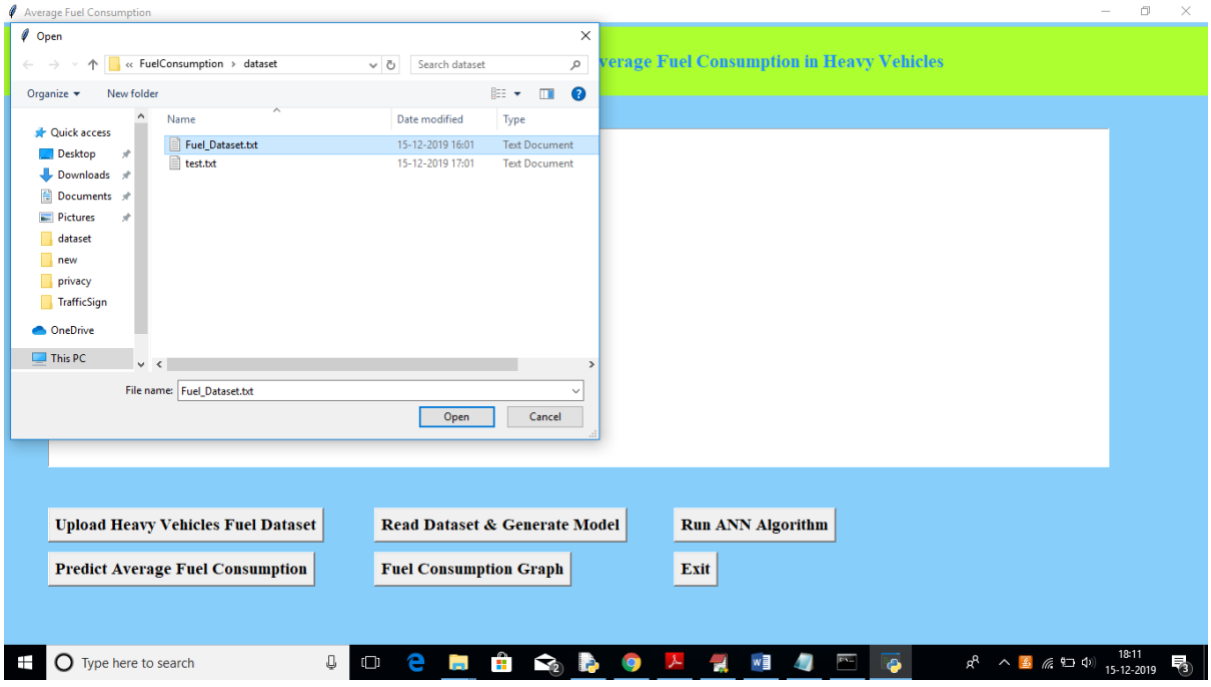
Fig: Class Diagram

Screenshots:

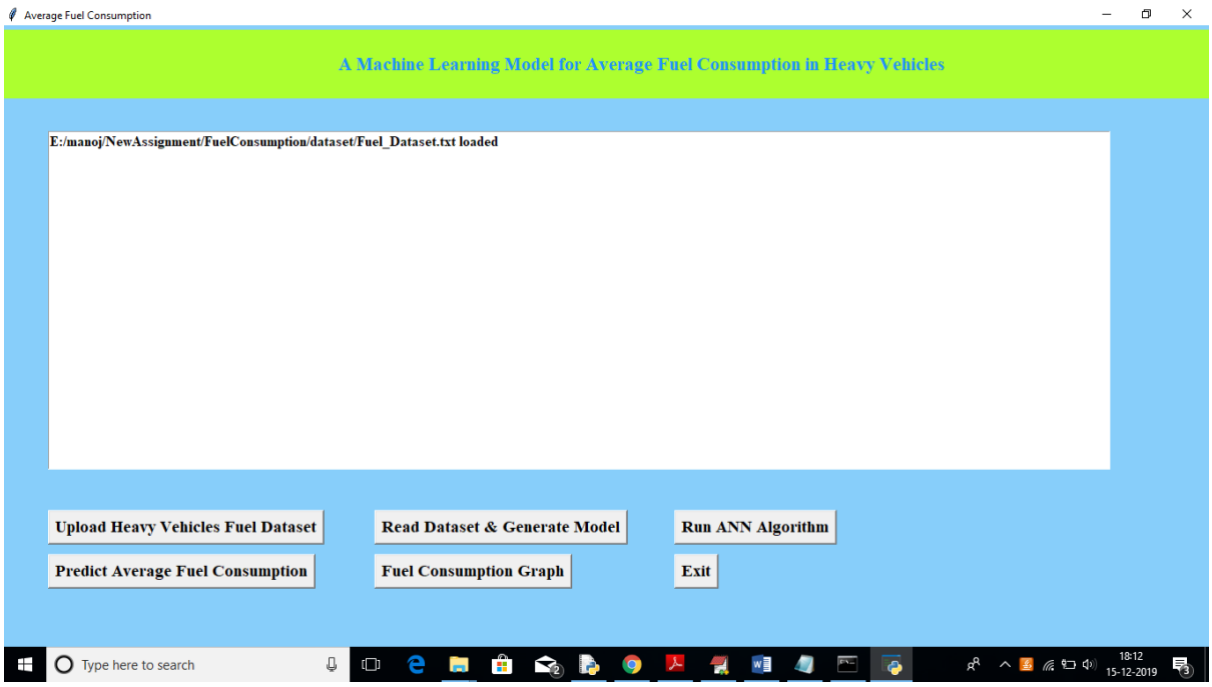
To run this project double click on 'run.bat' file to get below screen



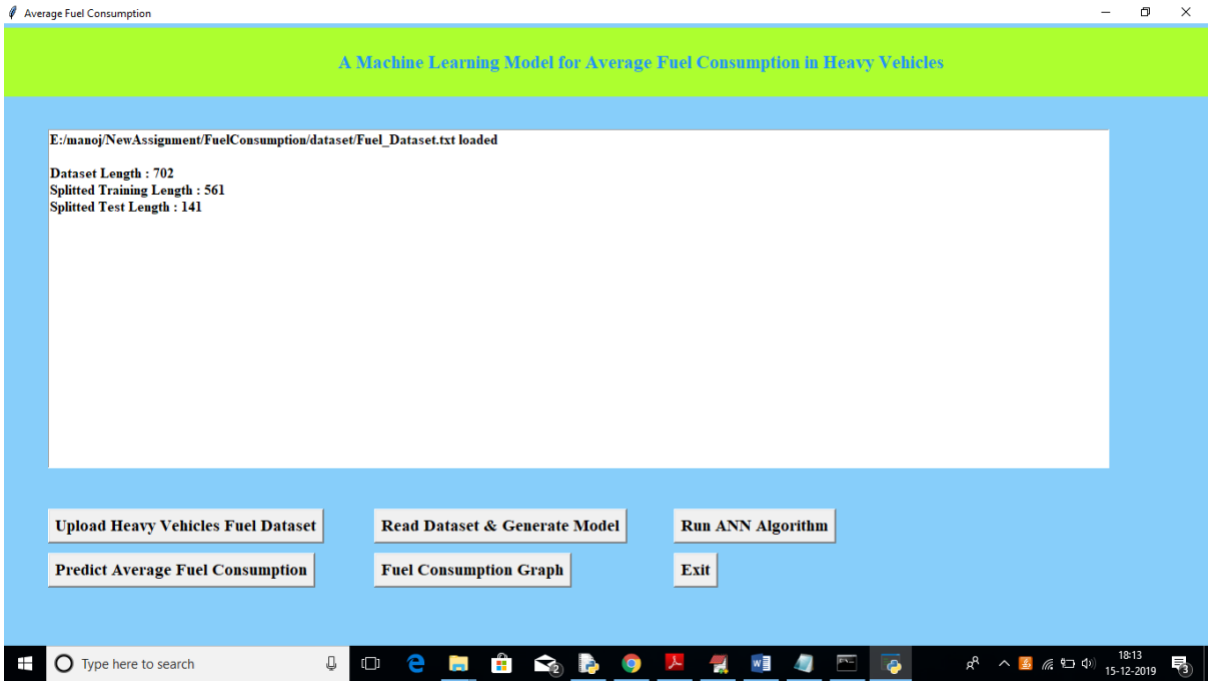
In above screen click on 'Upload Heavy Vehicles Fuel Dataset' button to upload train dataset



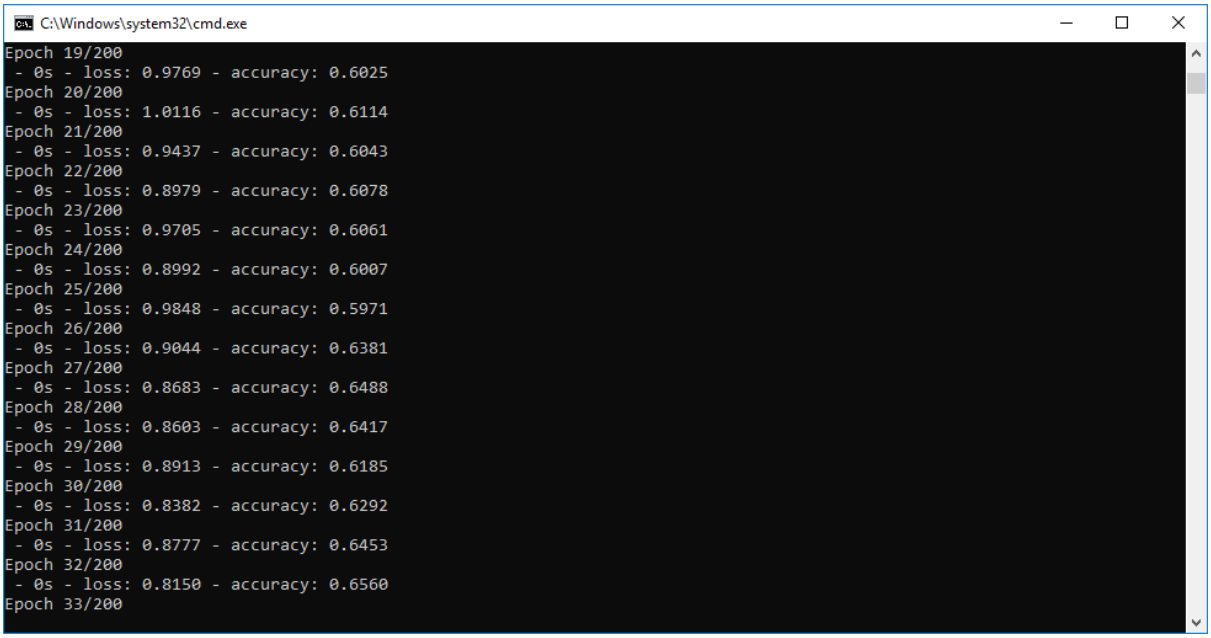
In above screen uploading 'Fuel_Dataset.txt' which can be used to train model. After uploading dataset will get below screen



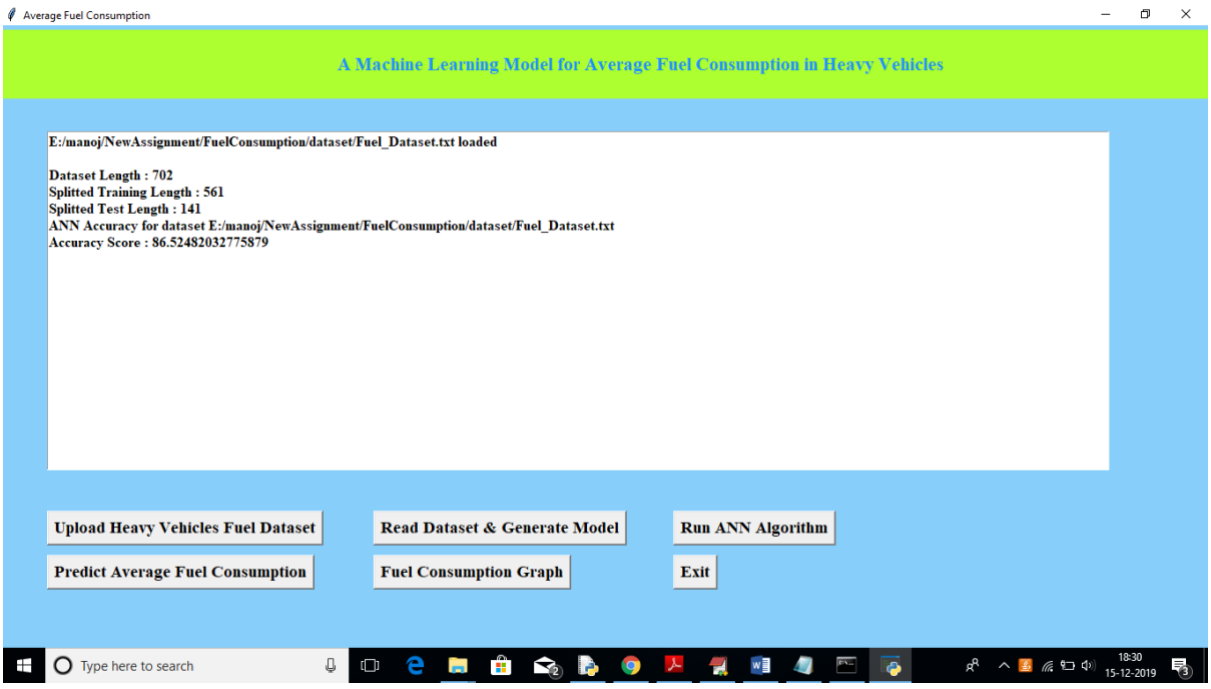
Now in above screen click on 'Read Dataset & Generate Model' button to read uploaded dataset and to generate train and test data



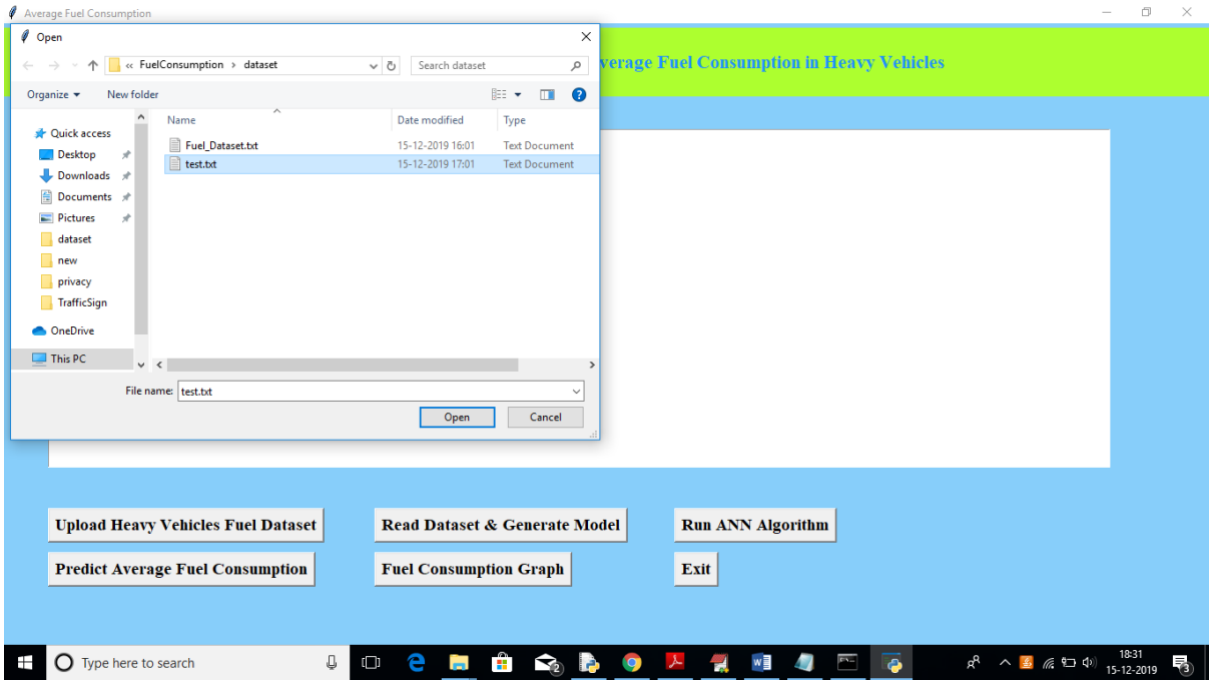
In above screen we can see total number of records in dataset, number of records used for training and number for records used for testing. Now click on 'Run ANN Algorithm' button to input train and test data to ANN to build ANN model.



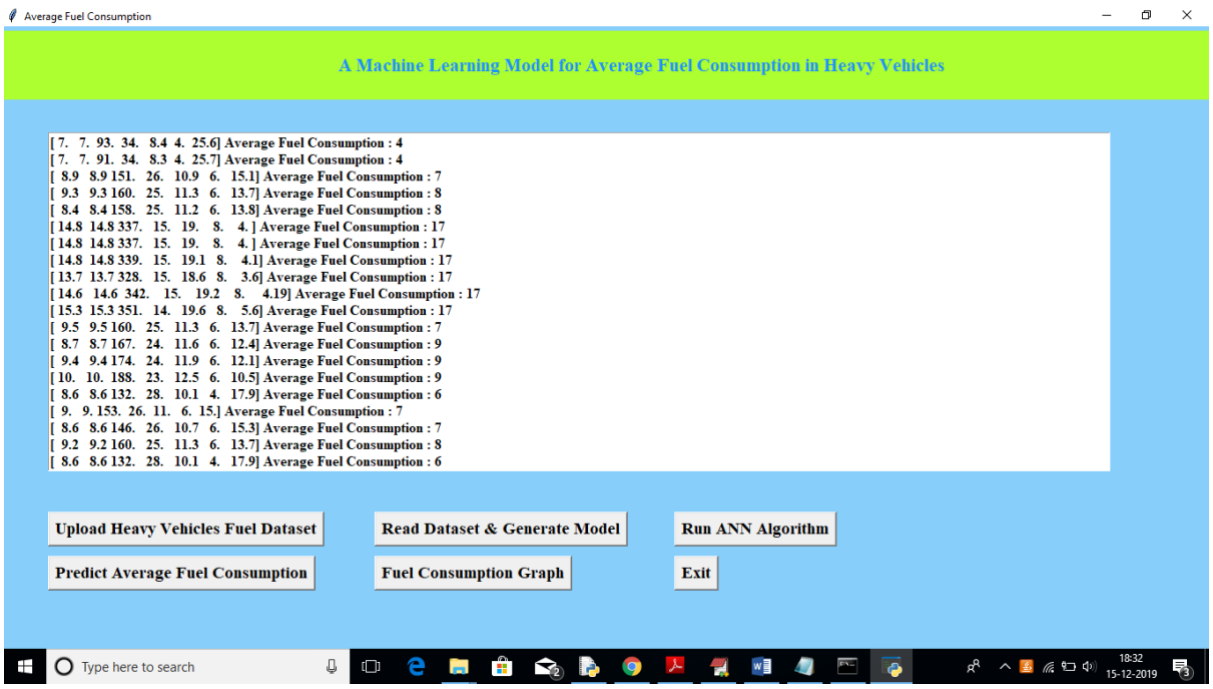
In above black console we can see all ANN processing details, After building model will get below screen



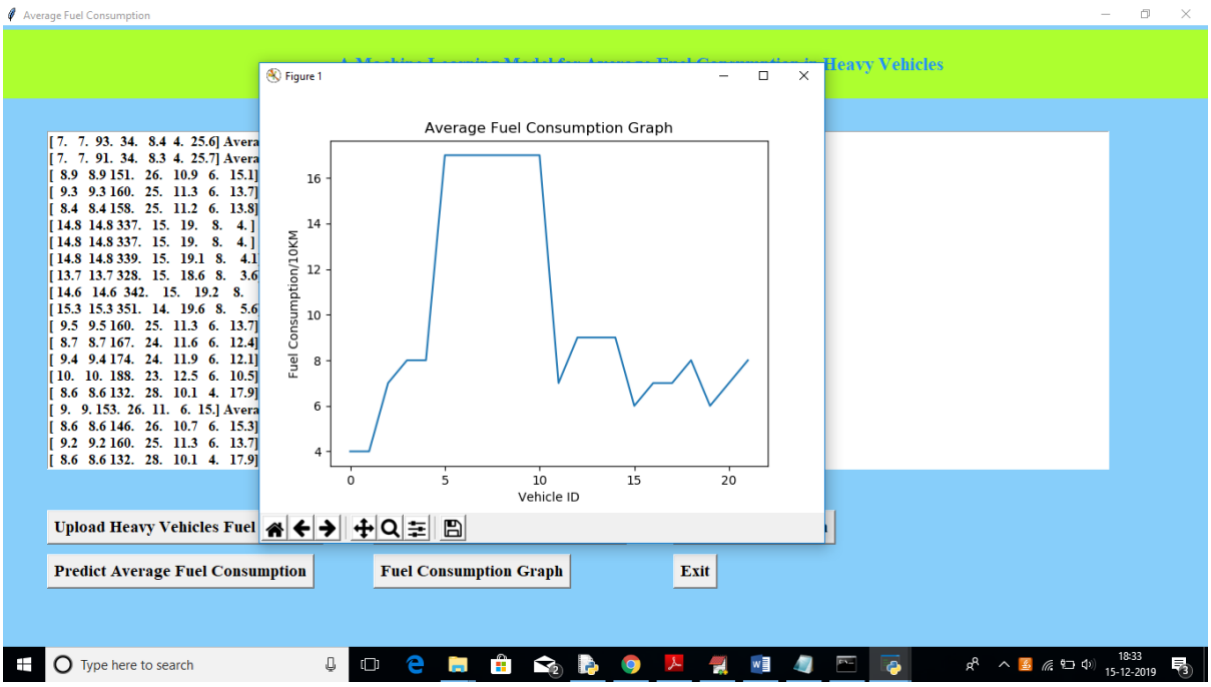
In above screen we got ANN prediction accuracy upto 86%. Now click on 'Predict Average Fuel Consumption' button to upload test data and to predict consumption for test data



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



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



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

Conclusion: Using this paper and ANN algorithm we are predicting fuel consumption for test data

5. LEARNING AFTER THE INTERNSHIP

This ‘Proternship’ gave us an opportunity to learn and build projects from scratch using Artificial Intelligence, Machine Learning and Python. It gave us thorough exposure to the field of Artificial Intelligence and nurtured us with its scope and usability in today’s world.

This project aided us in learning a new language and using this language we were capable of building real time projects which would help in our making day to day activities much simpler and easier.

6.SUMMARY/ CONCLUSION

This paper presented a machine learning model that can be conveniently developed for each heavy vehicle in a fleet. The model relies on seven predictors: number of stops, stop time, average moving speed, characteristic acceleration, aerodynamic speed squared, change in kinetic energy and change in potential energy. The last two predictors are introduced in this paper to help capture the average dynamic behavior of the vehicle. All of the predictors of the model are derived from vehicle speed and road grade. These variables are readaily available from telematics devices that are becoming an integral part of connected vehicles. Moreover, the predictors can be easily computed on-board from these two variables.

7.BIBLIOGRAPHY

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[2] G. Fontaras, R. Luz, K. Anagnostopoulus, D. Savvidis, S. Hausberger, and M. Rexeis, “Monitoring CO2 emissions from HDV in Europe-an experimental proof of concept of the proposed methodolgical approach,” in Proc. 20th Int. Transport Air Pollution Conf., 2014.

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