International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-12 Issue-2, December 2022

Low Fuel or Energy Alert System for Automobiles using Accelerometer Data

Amol Khatkhate, Jugal Jagtap, Ameya Nadkarni

***Abstract*: The focus of this paper is to develop a system which works on the real time data acquired by accelerometer ADXL345 as well as that from a smartphone mounted on the dashboard of the vehicle and calculates the amount of fuel consumed which is conveyed to the user. The algorithm is validated on 4 trips conducted around the Rizvi College campus and the results are found to be accurate. The algorithm works in real-time and can be implemented on any web interface to alert the driver via map-based navigation tools or to connect the driver to nearby local fuel supply stations. Similar activity will be carried out on vehicle batteries to estimate remaining useful battery life.**

***Keywords*: Fuel Estimation, Accelerometer, Alert System.**

I. INTRODUCTION

Accurate estimation of fuel is an important aspect in today's passenger vehicles as customers look for this aspect when considering buying a vehicle. The focus of this paper is to provide a smartphone-based algorithm which will capture the instantaneous changes that are happening while driving the vehicle and map those to the fuel consumed. The algorithm is tested on 4 trips around the college engineering campus and have been found to give consistent results. The algorithm is a simple equation that uses the kFE (fuel estimation constant) for a vehicle and outputs the amount of fuel used during travel. The accurate estimation can be further used in generation of big data where vehicles are connected to each other based on remaining fuel and hence, thereby lead to quick fuel supply as well relocation of gas stations on routes that are frequently used for commuting by users. The focus of this work is to validate the algorithm on daily commute trips by passengers and is shown for 3 trips around the Rizvi Campus.

Manuscript received on 28 November 2022 | Revised Manuscript received on 13 December 2022 | Manuscript Accepted on 15 December 2022 | Manuscript published on 30 December 2022.

***Correspondence Author(s)**

Amol Khatkhate*, Department of Mechanical Engineering, Rizvi College of Engineering, Mumbai (Maharashtra), India. Email: amolmk@eng.rizvi.edu.in, ORCD ID: https://orcid.org/0000-0001-7025-1372

Jugal Jagtap, Department of Mechanical Engineering, Rizvi College of Engineering, Mumbai (Maharashtra), India. Email: jugaljagtap@eng.rizvi.edu.in, ORCD ID: https://orcid.org/0000-0002-5758-1569

Ameya Nadkarni, Department of Mechanical Engineering, Rizvi College of Engineering, Mumbai (Maharashtra), India. Email: nadkarni_ameya@eng.rizvi.edu.in, ORCD ID: https://orcid.org/0000-0001-7327-4676

Section 1 gives the introduction, Section 2 discusses about the details of the algorithm, Section 3 discusses the trails that are conducted around the campus, Section 4 presents the results of the algorithm and Section 5 concludes the paper with further scope for future work. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either.

II. DETAILS OF THE ALGORITHM

The conventional fuel measurement instrument needs some type of interference or contact with the fuel tank either internal or external and the accuracy of such fuel measurement is limited to various factors of the instrument such as its reliability, efficiency, repeatability, and range.[1]
In this section we propose an algorithm to estimate the amount of fuel being consumed based on real-time acceleration data gathered in the x, y, and z directions either by a 3-axis accelerometer ADXL345 or a smartphone which can measure acceleration. Accelerometer data was collected from a used single owner Hyundai EON vehicle.
Data was collected for one trip to and fro on the same route and then analyzed to find a fuel estimation constant 'k_{FE}' which is vehicle model specific, and which varies with the vehicle inertia, vibrations, terrain and pattern of driving and usage. It will also depend on driver response like braking, pushing the pedal, abrupt turning, etc. Also, validation of the algorithm was done by setting a value of k_{FE} in a realistic scenario and indicating the time to refill to the driver. [2].
Sensor selection: Primarily the fuel consumed is correlated with the velocity and acceleration of a vehicle. The data used in acceleration in a one axis which is the driving direction. Accelerometer is also sensitive to vibrations and road conditions and will also depend on driver response like braking, pushing the pedal, abrupt turning, etc. Hence, this sensor works ideally for estimation of fuel.

A. Why instantaneous?

The vehicle runs on the same path for both the routes A and B. [2] However, still, instead of the average velocity, we consider the instantaneous sensor values for fuel consumed. This is because, the instantaneous values of acceleration and velocity are predominantly required for accurate fuel consumption while averaging effect will eliminate the driving behavior and result in loss of relevant information. The average velocity for the trip B is 3.89 m/s which gives a time of 1900/3.89 = 488 sec while for trip A is 4.11 m/s giving a period of 1900/4.11 = 462 sec, while in actual the time taken to complete the trip is about 200 seconds.

This clearly shows that the overall average is not reflecting the localized driving pattern and hence, instantaneous sensor readings are required to be considered in the estimation of fuel. The following steps are used in the algorithm:

a) Set the initial volume of fuel

b) Set the final threshold of fuel which needs to be indicated by the system for refill

c) Set sampling time using delay () function

d) Fuel consumed $V(t+1) = V(t) – k_{FE}*abs(A(t))$ where k_{FE} = constant (set to 0.00233 for Hyundai EON) depending on vehicle specifications like power, curb weight and engine displacement [3] and A(t) is the pertinent acceleration time series in the driving direction.

e) Provide suitable indications to the driver for refill.

III. RESULTS AND DISCUSSIONS

Acceleration data for all the 4 trips taken for analysis is with orientation in the X-direction which is the forward direction of travel of the vehicle.

For the 4 trips around college campus, average fuel consumed can be calculated from mileage of vehicle.

Trip distance = 450 m

Average time taken per trip = 75 seconds (from data recorded by app during trials)

Average speed = (450/75) m/s x 18/5 = 21.6 kmph = 13.5 mph

The multiplication factor is calculated from Table 2 in [2]

Factor = 13.5 - 10/ (15 - 10) = 0.7

From Table 1, the value is 23.1 + 0.7*(38.9-23.1) = 34.16 mpg = 34.16 x 1.6/3.6 = 15.18 kmpl at conditions tested as per Table 1 in [3].

For current road conditions, factor is divided by 4 as seen from Figure 1 [2] which gives 3.8 kmpl. In Figure 1, the blue and red curve are the real-time fuel consumption curves which indicate the fuel consumed during the trips A and B. The road conditions are very different than those when the mileage in Table 1 was generated which clearly is indicated by the green curve in Figure 1. The ration of the tip point of the green curve to the red or blue curve indicates the ratio of the effect of road conditions used for testing. This ratio is approximately = 0.25. Hence the mileage for current conditions is divided by 4 which gives 3.8 kmpl.

The fuel consumed on average is then given by 0.45/3.8 = 0.1184 liters (by algorithm)

Fuel remaining after each trip (on average) = 30 - 0.1184 = **29.88 liters (theoretical).** This is close to our calculation of the 3 trips which comes out to be **29.81 liters (actual)**

Table 1. Mileage of various class of vehicles with reference to average speed S(t)

Closest to Hyundai EON ⇩

Steady Speed Fuel Economy for Vehicles Tested in the 1997 Study (miles per gallon)

Speed (mph)	1988 Chevrolet Corsica	1993 Subaru Legacy	1994 Oldsmobile Olds 88	1994 Oldsmobile Cutlass	1994 Chevrolet Pickup	1994 Jeep Grand Cherokee	1994 Mercury Villager	1995 Geo Prizm	1997 Toyota Celica
5	10.0	14.5	10.5	5.1	7.9	8.2	12.3	18.1	19.1
10	16.8	24.7	14.9	7.9	16.0	11.2	19.0	23.1	34.1
15	17.7	31.9	22.2	11.4	16.3	17.5	22.4	38.9	41.7
20	21.7	34.4	26.3	12.5	19.9	24.7	25.8	39.4	46.0
25	23.9	37.4	28.3	15.6	22.7	21.8	30.8	41.7	52.6
30	28.7	39.7	29.0	19.0	26.3	21.6	30.3	40.0	50.8
35	28.6	38.0	30.9	21.2	24.3	25.0	26.1	39.1	47.6
40	29.2	37.0	33.2	23.0	26.7	25.5	29.0	38.9	36.2
45	28.8	33.7	32.4	23.0	27.3	25.4	27.8	42.3	44.1
50	31.2	33.7	34.2	27.3	26.3	24.8	30.1	39.1	44.8
55	29.1	37.7	34.6	29.1	25.1	24.0	31.7	37.7	42.5
60	28.2	35.9	32.5	28.2	22.6	23.2	27.3	36.7	48.4
65	28.7	33.4	30.0	25.0	21.8	21.3	25.3	34.1	43.5
70	26.1	31.0	26.7	22.9	20.1	20.0	23.9	31.7	39.2
75	23.7	28.8	24.0	21.6	18.1	19.1	22.4	28.3	36.8
				Fuel economy loss					
55–65 mph	1.4%	11.4%	13.3%	14.1%	13.1%	11.3%	20.2%	9.5%	-2.4%
65–75 mph	17.4%	13.8%	20.0%	13.6%	17.0%	10.3%	11.5%	17.0%	15.4%
55–75 mph	18.6%	23.6%	30.6%	25.8%	27.9%	20.4%	29.3%	24.9%	13.4%

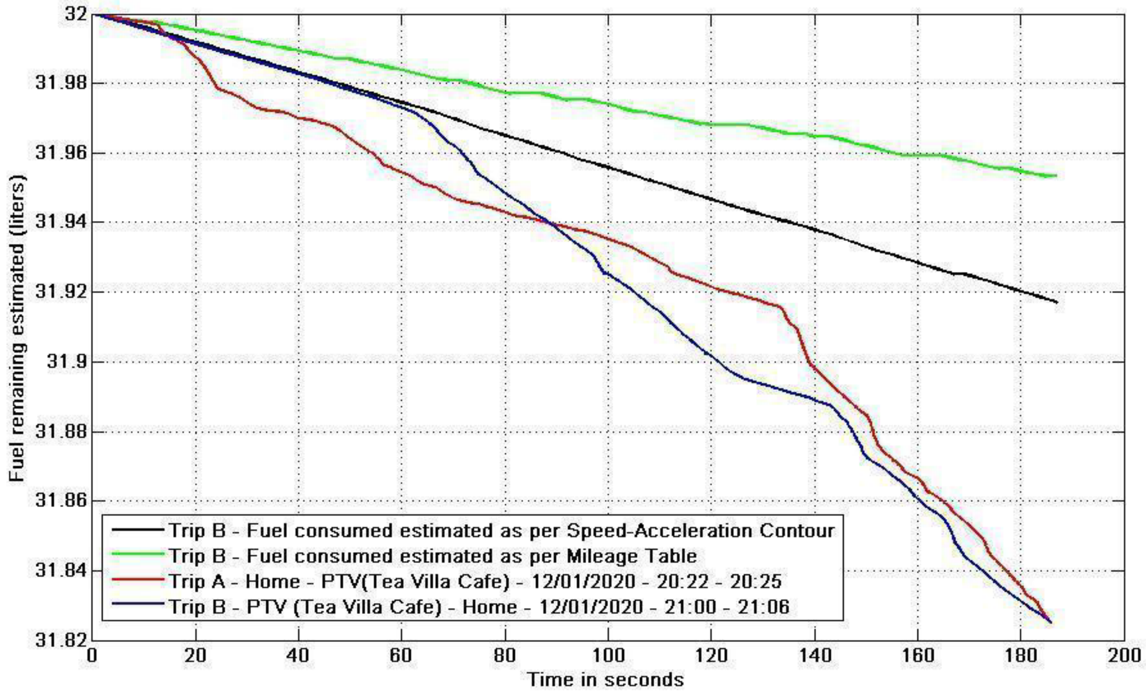

Fig 1.: Estimated fuel remaining v/s time

IV. CONCLUSIONS AND FUTURE WORK

The algorithm as seen is simple in nature and calculates the amount of fuel consumed based on real-time acceleration data. The fuel consumed is calculated based on the mileage of the vehicle which is derived from the Table 1 as seen in [2]. The time between samples is kept at 50 milliseconds and validation is done for 3 trips around the Rizvi College of Engineering campus. The output of the algorithm is seen in Figure given below

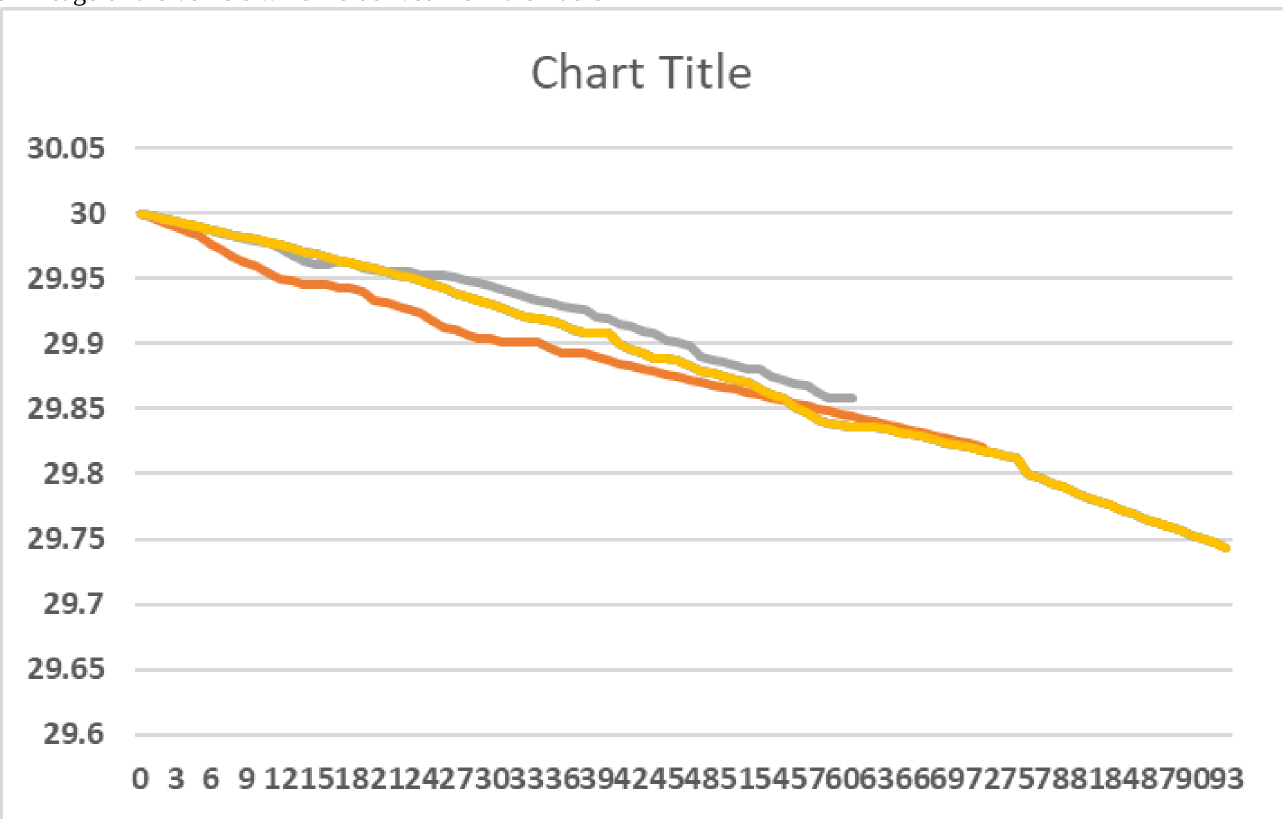

Fig 2. : Output of algorithm for 3 trips around RCOE

The algorithm shows the real-time behavior of the fuel consumed based on the acceleration data and k_{FE} calculated for the vehicle as shown earlier.

The three trips show the fuel remaining to be at 29.74, 29.82 and 29.86 liters respectively. The average fuel remaining for the three trips is at 29.81 liters. This is compared with the real data of the fuel remaining which is at 29.88 liters which is very close to the fuel consumed as indicated by the algorithm. The following aspects of the work can be carried out in the future.

1. The fuel consumed during the trips is a function of the instantaneous acceleration and hence, will reflect the jerks or changes in events that occur during the trip.
2. The value of k_{FE} and changes that occur in the same are indicative of the changes in road terrain and number of changes in acceleration for a constant amount of fuel consumed during a finite time interval.

In this paper, absolute value of instantaneous acceleration is considered for calculation purposes but, negative acceleration cases must be investigated in detail to check their effects on fuel consumption.

ACKNOWLEDGMENT

The authors would like to thank Mr. Naved Naik for helping in setting up the experiments related to the fuel consumption and accelerometer data on the dashboard of the Hyundai EON. The authors would like to thank the colleagues of Mechanical Engineering Department for their support in this work. The authors would like to thank Principal madam, Dr. Varsha Shah for her continued encouragement for pursuing research work related to this area.

DECLARATION

Funding	No funding.
Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethics Approval	Not relevant.
Consent to Participate	Not applicable.
Consent for Publication	Not applicable.
Availability of Data and Material	Not applicable.
Authors Contributions	The work has been jointly done by all the authors and the relevant results have been produced in the paper.
Code Availability	Not applicable.

REFERENCES

1. Vinay Divakar, Fuel Gauge Sensing Technologies for Automotive Applications, International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Volume 3 Issue 1, January 2014 41 ISSN: 2278 – 1323.
2. Mohammed Naved Naik, Amol M Khatkhate,Arnab Ganguly, Jugal Jagtap, Husain Jasdanwalla "An accurate non-intrusive method for fuel estimation of a passenger vehicle using real-time acceleration data from a smartphone", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.7, Issue 5, page no.1116-1126, May-2020, Available :http://www.jetir.org/papers/JETIR2005289.pdf
3. Afonso Vilaca, Ana Aguiar, and Carlos Soares, Estimating Fuel Consumption from GPS Data, IbPRIA 2015: 7th Iberian Conference on Pattern Recognition and Image Analysis, Santiago de Compostela, Spain.

AUTHORS PROFILE

Amol Khatkhate, has done his bachelor's degree from VJTI, Mumbai in 2001.He has completed his doctoral degree from Pennsylvania State University in 2006. He has been working as a faculty with Rizvi College of Engineering since 2015. His research interests are in mechatronics, robotics, and control systems. His publications can be accessed at Google scholar and has 150+ citations to his name.

Jugal Jagtap, has completed his M.Tech (Automotive Engineering, ARAI-CoEP); B.E. (Mechanical Engineering, SPCE). He has 6 years of rich experience in teaching in engineering domain related to dynamics of machinery, theory of machines, etc. Research Interest: Automobile Engineering, Mechanical Vibrations, NVH, Vehicle Dynamics

Ameya Nadkarni, has completed his bachelor's degree from Rizvi College of Engineering, University of Mumbai in 2009. He has completed his Master's degree from VJTI, Mumbai in 2015. His research interests are engineering mechanics, machine design, CAD and Additive manufacturing. He is serving as Head of Mechanical Department at Rizvi COE and is a vibrant faculty guiding students in areas of design.