

GPS based Energy Management System for Hybrid Electric Vehicle

Ishan Bhand⁽¹⁾, Aryendra Sharma⁽²⁾, Divyank Dubey⁽³⁾, C. Parag Jose⁽⁴⁾

Department of Electrical and Electronics Engineering
Faculty of Engineering
Christ (Deemed to be University)

Abstract— This paper introduces the design and implementation of a GPS based Energy Management System for Hybrid Electric Vehicle. The GPS data is mapped to the Altitude of the terrain and the information that is uploaded in the database controls the operation of the IC Engine and the DC Motor. The real time GPS data is used to perform switching of load between the IC Engine and motor. A Raspberry pi is the heart of the Energy Management System which ensures the reduction of the fuel consumption. The prototype of the system has been developed using Cloud services and integration of Raspberry Pi to the Drive train control.

Index Terms—EV, Global Positioning System (GPS), Raspberry Pi (RPi), Power Train, Cloud Computing, .

I. INTRODUCTION

The health risk of air pollution is becoming a serious problem and has contributed to more than half of the carbon monoxide and nitrogen oxides, and almost a quarter of the hydrocarbons emitted into our air. Hybrid electric vehicles (HEVs) are a promising advancement for lessening the amount of fuel that vehicles devour. Even though electric vehicles have been in the market as early as the 1800s', it has never been a viable option. Even though a lot of research has been done in this area, there is room for a lot more possibilities. The current scenario is usage of renewable & hybrid power based electric vehicle. Today on the Bengaluru roads alone a staggering number of 70.28 lakh vehicles are plying. Around 99% of them are IC engine based vehicles. This huge number of vehicles are solely dependent on fossil fuel based Petrol and Diesel to power up its propulsion. It not only causes environmental pollution but also is drastically reducing the fossil fuel amount on earth. The Hydrocarbons and other exhaust gases that are been injected into our environment is the main reason for different diseases among the masses ranging from lung disorders to cancers. The smog developed in cities like Beijing and Delhi and the high values of the Air quality Index in these places indicates the seriousness of the Air pollution. It is practically impossible to replace the IC engine vehicles all of a sudden and so the only option is to convert these IC Engine based vehicles into Smart Hybrid Systems that can reduce the consumption of fuel and at the same time reduce the exhaust.

The design proposed here is based on GPS based motor control switching between the motor and the IC engine. A survey conducted by Samuel E. de Lucena on electric and hybrid electric vehicle technology indicates the severity of the Air pollution due to IC engine based vehicles and the impact of hybridizing the vehicle on the ecosystem. The HEVs are the connecting link for the smooth transition of IC engine based vehicle to the eco-friendly noise free Electric Vehicles which is expected in the future. The excessive progress in EV technology, the consecutive blockade are still to be overcome, before all over the place use of HEV's, primarily due to battery cost, has to be decreased – which can be the conclusion of this time and future too on advanced technology of batteries. The propulsive range of hybrid electric vehicle has to be much extended , at cheap battery prices. The latter is very difficult problem , which demands cooperation of community to establish development in this field.

Parag Kulkarni et al demonstrated the expanding need for feasible transportation in the world and the part of the hybrid electric vehicle as a available solution.[1] Through technology survey and comparative study it shows that hybrid electric vehicle can help in decreasing harmful emission of toxic gases. It also gives abrupt information about hybrid electric vehicle , their classifications and types according to different parameters. Lihong Qiu et al. proposes a decentralised hierarchical global energy management control strategy for a group of connected four-wheel-drive hybrid electric vehicles (HEVs) in urban road conditions.[2] In the higher level controller, signal phase and timing information and the optimal cruising velocity are combined to generate the target velocities for the HEVs. A model predictive control framework that focuses on the tracking of the target velocity and the associated desired control variable for every individual vehicle is proposed for the prediction of the optimal velocity that compromises fuel economy, mobility and safety. In the lower level controller, a dynamic programming problem is formulated that utilises the predicted velocity for the global energy management optimisation of every individual HEV. Thomas Miro-Padovani et al. describes a method combining fuel consumption and drivability constraints has been proposed.[3]

Wassif Shabbir et.al in his paper proposes an an Exclusive OR strategy that is better than the Global Equivalent Consumption Minimization Strategy (GECMS).[4] The Dynamic Programming (DP) is determined as not feasible for complex vehicles and so in the paper an idea is developed where a Series HEV and makes use of a DC link to integrate the two systems. The paper also compares Thermostat Control Strategy (TCS) and Power Flow Control Strategy (PFCS) which are conventional strategies. The strategy makes use of three modes of operation and it is a smoothened version of GECMS.

The drivability constraints include gear positioning, engine parameters, wheel torque reserve. It makes a comparison with the non-causal strategy Determinist Dynamic programming (DDP) where knowledge of the future driving conditions is obtained. The proposed system which is an online strategy is based on the ECMS which takes data online. But the drawback is it is unable to process minute changes like acceleration/deceleration if the changes are lower than the sampling period. The need for a pseudo predictive control system is high to have a optimised operation of the Energy Management System.

II. PROPOSED SYSTEM

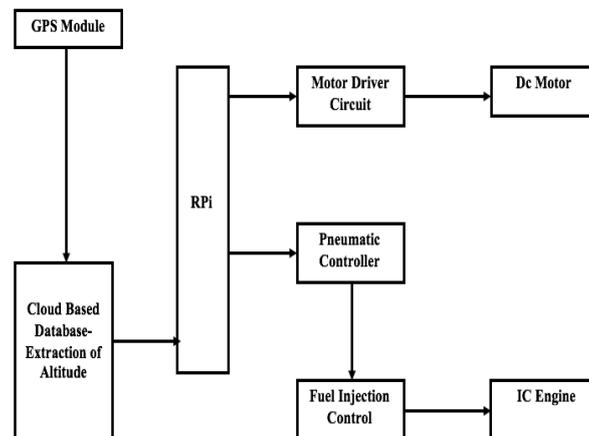


Fig 1: Block Diagram of the Proposed System

The Electric motors has its operating characteristics similar to the ideal characteristics expected from a propulsion system and thereby works with single transmission while an IC Engine based system has to have a gear system to match with the ideal operating characteristics. The initial torque given by an Electric motor based vehicle is much higher than that which can be extracted from an IC Engine based vehicle. When the terrain is steep the IC engine based vehicle has to operate at a lower gear position to extract the required torque which causes consumption of more fuel and incomplete burning of the fuel in the combustion chamber ultimately results in release of unburned hydrocarbons and other exhaust which would further pollute the environment. This problem is addressed by the proposed system where in based on the altitude of the road the load is switched between the IC engine and the Motor. The motor is made to take up majority of load at conditions where the altitude is high and where normally the IC Engine would have to operate at a lower gear to produce the required torque. The Energy Management System developed is based on mapping the Co-ordinates of a location with the data base and from the database the altitude of the location is retrieved. This data is then extracted from the cloud and given to the Raspberry Pi which then regulates the voltage given to Motor Driver control Unit and the IC Engine Fuel Injection system as shown in Fig.1. The implementation of the system has been tested using the Pneumatic controller in the FESTO lab where the motion of the Pneumatic controller has been implemented. But due to the miniaturized` model the implementation of the Pneumatic controller and the IC Engine control has been mimicked using a DC motor. The IC Engine connected to the differential at the front wheels has been replaced by a DC motor powering the front wheels. The operating characteristics of a 254 cc 4 gear 4 stroke petrol Engine has been evaluated and found that the characteristics when operated with the all the four gears gives a characteristics which can be obtained from conduction of load test on a 2 kw shunt motor with single transmission. The prototype made has been scaled down and the GPS control has been implemented based on load sharing between the front and rear end motors.

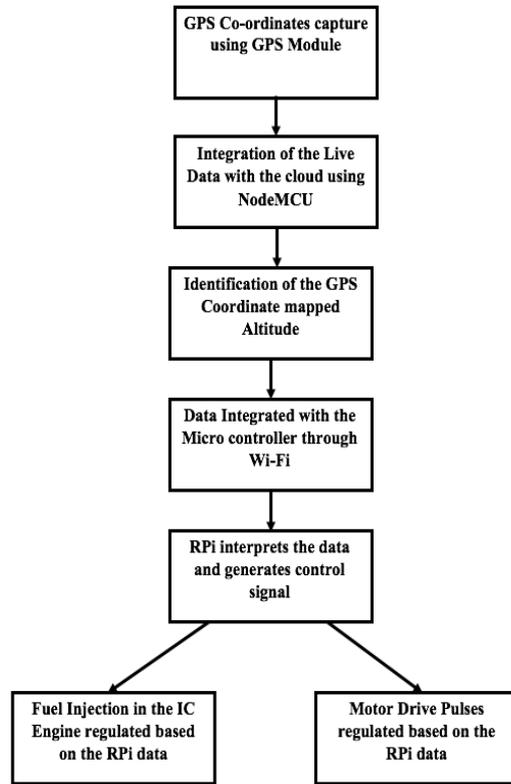


Fig 2: Flow Chart of the Energy Management System

Fig 2 shows the flow chart of the implemented Energy Management system. The live data is captured using the GPS module and the data is transmitted over WiFi to the Rpi which in turn implements the control of the front and rear end motors.

III. GPS – ALTITUDE CLOUD INTEGRATION

The database that is developed is based on an in-campus path. The GPS unit was taken over the stretch of road in campus and the Latitude, Longitude co-ordinates and the Altitude is marked. This data is uploaded in the cloud and accessed by the Rpi based controller attached to the vehicle set up in the Lab. The data is also accessed using the PC to have an interface of the data to be displayed for easiness of analysis. Fig 3 shows the data that has been uploaded by the GPS unit extracted and viewed through the PC Interface. Thingier.io cloud console interface is used as the interface for the data extracted from the cloud.

Date	alt	lat	lon
2018-03-19T11:12:51.973+0530	775.1	12862292	77438809
2018-03-19T11:12:50.051+0530	773.4	12862297	77438804
2018-03-19T11:12:47.596+0530	771.1	12862249	77438803
2018-03-19T11:12:44.723+0530	769.9	12862241	77438806
2018-03-19T11:12:42.883+0530	768.4	12862223	77438805
2018-03-19T11:12:40.587+0530	767.3	12862203	77438834
2018-03-19T11:12:35.404+0530	766.2	12862165	77438898
2018-03-19T11:12:33.404+0530	766.7	12862180	77438872
2018-03-19T11:12:31.697+0530	766	12862154	77438731
2018-03-19T11:12:27.396+0530	765.2	12862144	77438750

Fig. 3: GPS data captured and logged in the Cloud

The Fig. 4 shows the captured latitude and longitude locations and the altitude represented using a plot. This data is also transmitted to the Rpi which then uses the data to regulate the load sharing.

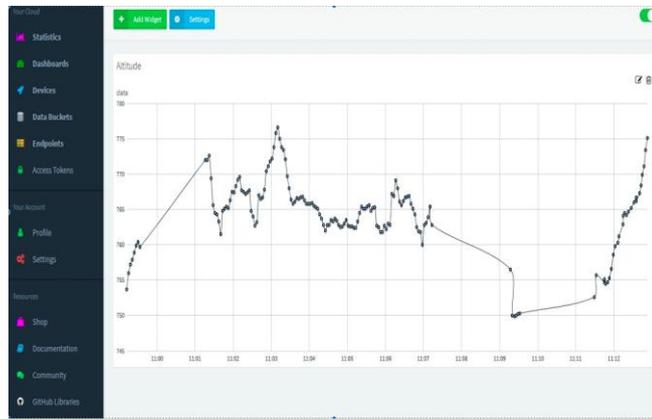


Fig. 4: GPS data and Altitude plotted for Rpi reference

The plot depicts the variation in the altitude clearly over the course of time when the GPS module is moved from one point to the other. The live data is sampled at a very high rate and so dynamic changes can be accommodated in the Energy Management System.

IV. ENERGY MANAGEMENT AND LOAD SHARING

The Energy Management system developed works on the logic of sharing the load between the DC motor and IC Engine. The algorithms for each co-ordinate captured by the GPS unit is fed live to the Rpi over WiFi which is then evaluated by the Algorithm to perform load sharing. If the slope (the difference in altitude of present sample and the next sample) remains the same then the IC Engine takes up 100 percent of the load i.e the DC motor does not provide power for propulsion. But as the altitude increases and the slope increases the load sharing begins turning on the motor and contributing to the propulsion. Fig.5 shows the analysis of the data based on the Algorithm developed using Python in Rpi and shows the load sharing being performed. It can be noticed that as the altitude increases the load sharing by the motor increases to 20 percent and subsequently to 54 percent. As the altitude goes on increasing the motor contribution become 100 percent and the IC Engine contribution becomes zero.



Fig. 5: Implementation of Load Sharing Control on the Rpi

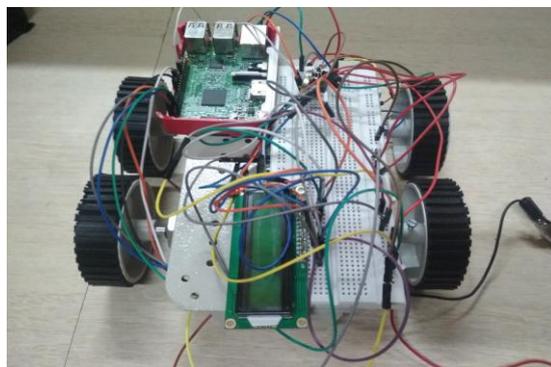


Fig. 6: Implemented Model of the Prototype

Fig 6. Shows the implemented system. The LCD display shows the load sharing between the Front Wheel and Rear Wheel power sources. Based on the data which is captured from the GPS unit and the live data received by the Rpi the decision to switch between the front end and rear end power source is performed. This is shown as percentage in the LCD display.

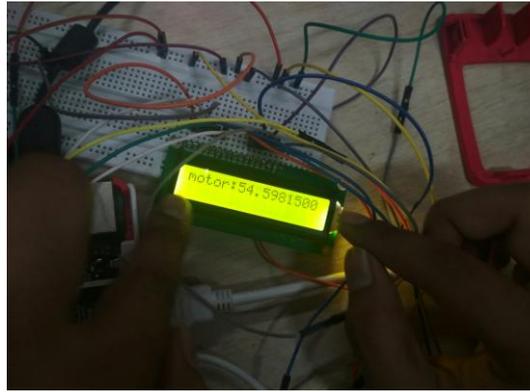


Fig. 7: Display of the Load Sharing

Fig 7, shows the display as indicated by the display. Here the motor carries the load percentage of 54.59% while the remaining 45.41% of the load is taken up by the IC Engine. So based on the altitude the load sharing between the IC Engine and the Motors are successfully shared. The Energy Management System therefore can optimize its operation based on the altitude that it is travelling.

CONCLUSION

The paper introduces a novel Energy Management System where the Load is shared between the Rear and Front Power Sources based on the Inclination of the road. It is an attempt to develop a Pseudo predictive Energy Management system where the information regarding the Altitude at each location is made available to the controller so as to be prepared for the load sharing. Here due to constraints in implementing fuel injection control the IC Engine operation is mimicked using a pair of DC hub motors by regulating the voltage given to them. The GPS based data logging and Rpi based regulation of the load enables to make the system more optimized in its operation.

ACKNOWLEDGMENT

We take this opportunity to acknowledge Faculty of Engineering, Christ University for providing us with the Control Systems, Power Electronics, Electrical Machines, FESTO Lab and Automobile Engineering labs and facilities for the research work involved in development of paper.

REFERENCES

- [1] Parag Kulkarni, "Review of Hybrid Electric Vehicles" International Journal of Emerging Research in Management & Technology ISSN: 2278-9359 (Volume-4, Issue-3)
- [2] Lihong Qiu; Lijun Qian; Hesam Zomorodi; Pierluigi Pisu, "Global optimal energy management control strategies for connected four-wheel-drive hybrid electric vehicles" IET Intelligent Transport Systems (Volume: 11, Issue: 5, 6 2017)
- [3] Thomas Miro-Padovani; Guillaume Colin; Ahmed Ketfi-Chérif and Yann Chamailard, "Implementation of an Energy Management Strategy for Hybrid Electric Vehicles Including Drivability Constraints," IEEE Transactions on Vehicular Technology, Year: 2016, Volume: 65, Issue: 8, Pages: 5918 - 5929.
- [4] Wassif Shabbir and Simos A. Evangelou. "Exclusive Operation Strategy for the Supervisory Control of Series Hybrid Electric Vehicles," *IEEE Trans. Control Systems Tech.*, vol.24, no. 6, pp.2190-2198, Nov.2016.
- [5] Lihong Qiu, Lijun Qian and Hesam Zomorodi, "Global optimal energy management control strategies for connected four-wheel-drive hybrid electric vehicles," *IET Intelligent Trans. System.*, vol.11, no. 6, pp.264-272, May 2017.
- [6] Samuel E. de Lucena. A Survey on Electric and Hybrid Electric Vehicle Technology, Electric Vehicles – The Benefits and Barriers, Dr. Seref Soylu (Ed.), ISBN: 978-953-307-287-6, InTech,
- [7] Feng Tianheng, Yang Lin, Gu Qing, Hu Yanqing, Yan Ting and Yan Bin "A supervisory Control Strategy for Plug-In Hybrid Electric Vehicles Based on Energy Demand Prediction and Route Preview," *IEEE Trans. Vehicular Tech.*, vol.64, no. 5, pp.1691-1700, May 2015.
- [8] Emilia Silvas, Theo Hofman, Nikolce Murgovski, L.F Pascal Etman and Maarten Steinbuch. "Review of Optimization Strategies for System-Level Design in Hybrid Electric Vehicles," *IEEE Trans. Vehicular Tech.*, vol.66, no. 1, pp.57-70, Jan.2017.
- [9] S. A. Zulkifli, S. Mohd, N. Saad and A. R. A. Aziz " Split-parallel through-the road hybrid electric vehicle: Operation, powerflow and control modes," *IEEE Transportation Electrification Conference and Expo (ITEC)*, Aug. 2015.

- [10] Tariq Kamal, Syed Zulqadar Hassan, Sidra Mumtaz and Laiq Khan , “PV based PHEVs smart charging station facility,” : Power Generation System and Renewable Energy Technologies (PGSRET), 2015, 10-11 June 2015.
- [11] Deepesh S kanchan, and Niranjana Hadagali, “Bidirectional Dc/Dc Converter System For Solar And Fuel Cell Powered Hybrid Electric Vehicle,” International Conference on Magnetics, Machines & Drives (AICERA-2014 iCMMMD).
- [12] M.Kaleeswari, and Dr.K.Lakshmi, “Energy Management for Plug in Hybrid Electric Vehicles Using Stochastic Optimization,” 2015 International Conference on Advanced Computing and Communication Systems (ICACCS -2015), Jan. 05 – 07, 2015, Coimbatore, INDIA.
- [13] Y. H. Hung, C. C. Chang, C. H. Wu and P. Y. Chen . Model Establishment and Performance Assessment for Active Regenerative Braking System of Electric Vehicles. The 14th IFToMM World Congress, Taipei, Taiwan
- [14] Maksym Spiryagin , Peter Wolfs, Frank Szanto , Yan Quan Sun , Colin Cole and Dwayne Nielsen. Model Application of flywheel energy storage for heavy haul locomotives. Special Issue of Clean Transport- Applied Energy 157 (2015) 607–618.
- [10] Cikanek, S.R., and Bailey, K. E. 2002. Regenerative Braking System For A Hybrid Electric Vehicle. Proceedings of American Control Conference. 4:3129-3134.
- [11] Gao H., Gao Y., and Ehsani, M. A neural network based SRM drive control strategy for regenerative braking in EV and HEV. IEEE Int.Electric Machines and Drives Conference: 571 – 575.
- [12] M.V. Palandurkar, M. A. Chaudhari, J. P. Modak and S. G. Tarnekar. Cycloconverter Based Three Phase Induction Motor to Replace Flywheel of the Process Machine. IEEE PEDS , Bangkok-2007

