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IoT Based Electric Vehicle Application Using Boosting Algorithm for Smart Cities

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Abstract: The application of Internet of Things (IoT) has been emerging as a new platform in wireless technologies primarily in the field of designing electric vehicles. To overcome all issues in existing vehicles and for protecting the environment, electric vehicles should be introduced by integrating an intellectual device called sensor all over the body of electric vehicle with less cost. Therefore, this article confers the need and importance of introducing electric vehicles with IoT based technology which monitors the battery life of electric vehicles. Since the electric vehicles are implemented with internet, an online monitoring system which is called Things Speak has been used for monitoring all the vehicles in a continuous manner (day-by-day). These online results will then be visualized in MATLAB after an effective boosting algorithm is integrated with objective function. The efficiency of proposed method is tested by visual analysis and performance results prove that the projected method on electric vehicle is improved when using IoT based technology. It is also observed that cost of implementation is lesser and capacity of electric vehicle is increased to about 74.3% after continuous monitoring with sensors.

Keywords: electric vehicle; Internet of Things (IoT); sensors; capacity; cost

Citation: Urooj, S.; Alrowais, F.; Teekaraman, Y.; Manoharan, H.; Kuppusamy, R. IoT Based Electric Vehicle Application Using Boosting Algorithm for Smart Cities. *Energies* **2021**, *14*, 1072. https://doi.org/10.3390/en14041072

Academic Editors: Joao Ferreira and Islam Safak Bayram

Received: 28 December 2020
Accepted: 9 February 2021
Published: 18 February 2021

1. Introduction

In recent days there are more changes in vehicle manufacturing, where all companies have advancement in production of vehicles and they are moving towards a smart vehicle environment. Thus, the usage of old engines have been replaced by new ones that produces much fewer hazards to the environment. In this way, electric vehicles which produce much less pollution have been introduced with many facilities which are very similar to normal vehicles that are present now. The speed, range and efficiency of electric vehicles are nearly equal when compared to diesel and petrol engine vehicles. In addition, these electric vehicles have a battery source which provides good benefits for travelling long distances. The users can select the type of battery and they can even monitor the charge in battery with the location of charging station. In this monitoring stage, a new monitoring device which replaces the old technology of Global Positioning System (GPS) has been integrated in necessary parts of electric vehicles. The same work of GPS has been done by an intelligent device called wireless sensors. Even the sensor technology in electric vehicles will be more advantageous than GPS devices. Therefore, this integration of wireless sensors in necessary parts of vehicles can be able to monitor the parameters like battery efficiency, distance of travelling, alert on charge and charging stations etc.

If wireless sensors are used then it becomes easy for all users in maintaining their vehicles. Even the introduction of electric vehicles will create a user-friendly environment and all the areas can be converted to smart cities and smart villages. In addition, these electric vehicles will also be much helpful during heavy traffic condition because a sensing device is installed in it which will be able to monitor all traffic situations. Even this technology can be extended on detecting humans in case of mild cardiac attack where many accidents can be avoided. However, in normal vehicles this new technology cannot be introduced because the implementation cost will be higher and temperature of the systems will not be able to support this technology. All users can relish many complexities at much reduced cost and life time of electric vehicles will also be much higher when compared with old generation engine vehicles.

The proposed work aims to provide an Internet of Things (IoT)-based solution for controlling the charges in vehicles and examines its usage in outdoor environments by transmitting data to long detachments. The purpose behind this projected method is to save the life of individuals because there is a possibility that the system will result in a short trail which in turn causes severe damage to human life. Therefore, the main findings of the proposed work are to analyze the maximum limits of charge capacity with limitations in voltage sets. These parameters will be calculated using a gradient boosting algorithm where prediction error will be lesser. Since this technique considers a data transfer methodology where the analyzed information will be transferred to control center it is necessary to use an IoT-based technology at low cost of implementation.

1.1. Literature Survey

To understand the establishment of proposed work it is necessary to examine the existing literature and to determine how the parameters are monitored. In addition, it is important to validate how efficiency of other integrated algorithms is improved. Therefore, IoT, which is integrated with the smart grid, has been analyzed for integrating different energy systems [1]. The major background on examining Reference [1] is that it provides clear information about different communication technologies and their integration over various IoT applications. Further, Reference [1] describes the development and transformation of different information and communication technologies that can be implemented for smart grid process. However, in Reference [1] compete validation of different technologies have not been compared therefore analyzing the exact advantage is a challenging task. For converting all cities into highly developed ones an intelligent device is introduced for wide spread operation [2]. The authors discussed four main parts which included generation, transmission, distribution and retail for converting the cities into smart ones. Further, the authors have surveyed the importance of solar and wind energy and their distinct advantages for implementing it in the smart gird process. Here also the authors have not compared both processes and it again becomes a challenging task for implementing the exact technological process [2].

For making the cities to be smart it is very important to implement charging stations with distributed charging schemes [3]. In Reference [3] a new method of integrating residential building for smart charging process has been projected, where different state of charge levels have been obtained with a reduced electricity bill. However, there is no intelligent device that is used for monitoring critical situations of failure which is considered as the main drawback [3]. However, immense demand that is changing in day-by-day activities has been addressed using an IoT process. After some innovative process like IoT, block chain technology has been introduced for data encryption [4], where it is integrated for calculating the exact battery level with indication of charging stations. However, the usage of block chain technology is not necessary for checking the amount of battery level. If the proposed model is analyzing any important parameters like security then block chain can be implemented. However, a complete battery management system has been presented with a data sharing policy. This type of decentralized scheme can be embedded using IoT but the major drawback is that cost of implementation encrypted systems is much higher which is not even necessary for monitoring the battery level of electric vehicles. Even the authors have added that real time confirmation of battery levels is not necessary which forms more misperception on projected technological process [4].

IoT technology has been enabled for monitoring all important parameters in electric vehicles mostly for observing the amount of power that is controlled during charging process. In line with above concern, a smart charging control process has been introduced [5] for saving unnecessary wastage of power in the home. Here, IoT plays an important role for monitoring both full and empty battery level and it sends an alert message to all connected users. Additionally, another method has also been designed for inter vehicular users using a group of wireless networks. However, this client server model will not work if quality of network is poor and no exact analyses in node energy consumption have been discussed [5]. Since load forecasting is very necessary for incorporating real time electric vehicles the same strategy is followed by introducing a method for monitoring all charging stations [6]. A big cloud platform has been created thus creating a real time view using an IoT process. However, for electricity price there is no possibility that it can vary with time but instead a reduced cost of implementation would be very helpful for investigating the necessary case studies with correct state of charge formulations [6]. Further, a new optimal method for estimating the distance and level of battery has been used which provides a good idea for implementing the proposed work.

Since IoT is an automation process, if any problem arises in such an automatic process during charging of electric vehicles, then a swapping method in charging station is introduced [7] by sharing all necessary information through the internet only to particular authorized users. In this case there is a need for block chain technology and if it is combined with IoT, then sharing of information will be secured. Even though the authors have introduced a combined communication method for handling large data, encrypting the data only to authorized users has not been discussed [7]. Additionally, for ensuring safe operation in electric vehicles it is very important to switch off the engine which provides complete safety rather than swapping. Therefore for avoiding excessive charging of batteries, a new state of charge by coulomb counting method has been introduced with an Android application platform [8]. In Reference [8], a mini computer with very high information storing capacity has been devised using a raspberry-pi module. Additionally, this raspberry-pi works with an IoT platform called node red for monitoring the status of battery and the results are monitored and sent to a particular user at all discrete intervals. This high processing device is much easier to implement and even more parameters can be monitored. However, only battery charging has been monitored by using such efficient technique without discussing any other advantage of sensor technologies.

The same method as discussed in Reference [8] has been followed [9] without any raspberry-pi processor for monitoring the performance of electric vehicles and to stop the degradation process. Here for a simple operation is provided by using many sensors which includes voltage, current and temperature sensors. Additionally, the data are integrated and sent to requested users using Global Positioning System which is connected with Google maps. The major drawback is that very accurate information cannot be obtained in the case of a low processing device and data aggregation is not possible with the help of GPS [9]. However, the method can be implemented at low cost and no there is no need for users to buy a new technology-based platform, and if all sensors are fabricated in to a single use then more cost will be saved. Furthermore, an advanced technology which includes a new concept of buying and selling power in charging stations has been introduced [10]. This method discusses all different scenarios using solar, wind and diesel generators but for charging electric vehicles a very complicated process is not required at a much higher cost. If this process is implemented in real time, then space required for such an operation should be much higher which is not possible for all business persons [10].

The fundamental procedure for all methods discussed [9,10] upstretched by using a coil where the devices are charged in a wireless medium [11]. Before implementing raspberry-pi module, an Arduino-based method has been introduced but the authors have assured that the efficiency of the charging station will be increased which is not possible. Whereas, if the efficiency of vehicle is increased then a new method can be developed with some efficient processors. In line with above concern the same Arduino method has been extended with block chain technologies [12]. If the suggested method is introduced then limitations on power will be solved but high cost of implementation is observed as a major drawback [12]. Exploring the role of IoT in the energy sector has been briefly discussed in [13] where the more challenging task on implementation procedure has been given and useful information for real time implementation of the proposed method can be obtained. Similarly, a survey on the big analytics process is also carried out with different communication technologies and thus providing information on standardization models [14]. Recently the authors [15] have explored revenue-based electric vehicle charging stations, where each individual can reduce the charging time by using wireless technologies at their present position. Consequently a new concept has been designed where, during the autonomous driving process, wireless chargers will be installed inside the vehicle [16] and this operation is referred to as Internet of Vehicles (IoV). However, even for small vehicles, if a wireless charging method is introduced [15,16] then users have to afford a high cost and at the same time flexibility will be higher because the users can charge at their current position. In addition, a block chain technology is introduced for managing battery and to store data in an efficient manner [17,18]. However, if a block chain technology is introduced then a semi centralized solution will be obtained. Therefore, to overcome the hindrance in References [17,18] an optimal path selection with block chain technology is enhanced where robust equivalent reports will be obtained inside the charging load.

1.2. Research Gap and Motivation

This research work identifies the gap that is present in existing methods, where all parameters like capacity, distance, temperature and cost are not monitored completely [19–28]. Even though an authoritative security process is integrated in References [19,20] the main parameters that contribute to evolution of electrical process in designing part are mislaid. The perception of battery management system is which identifies overcharging and excess current flow using IoT process has been described [21] with high temperature variations in circuit. However, the data unit facility provided for circuit integration is much lesser. Additionally, a smart parking system has been introduced which provides a virtuous basic acquaintance on modifying the same process by scanning the number plate of the vehicle [22]. In addition, the same basic principle has been minimized by avoiding high traffic condition using a direction enabled Android platform [23]. For both aforementioned processes [22,23] a high end prototype is built, but even more research has been performed for designing the same using a low cost processor [23–28] by integrating wireless sensors. However, to have complete knowledge on IoT and to understand the importance of the sensing device, it is necessary to calculate all the parameters in the electric vehicle. The use of an electric vehicle to reduce environmental hazards by integrating IoT has been lying as motivation for authors and all gaps in parametric evaluation have been overcome by implementing the proposed method in real time.

1.3. Objectives

The major aim of proposed work is to analyze the usage of electric vehicles by incorporating IoT thus satisfying the following objectives which includes maximization of (i) capacity (ii) battery life at long distance and minimization of (i) cost (ii) temperature. For achieving the objectives a gradient boosting algorithm is also implemented and maximum efficiency is achieved.

2. Problem Formation

In this section a new model for electric vehicles which are connected by IoT has been formulated. For an electric vehicle it is very important to know the status of battery that determines the health of vehicle which is given by Equation (1),

$$b(i) = \sum_{i,n=1}^{\infty} \frac{C_i}{C_n} \tag{1}$$

where,

C_i denotes the current capacity that is observed at the output;

C_n represents the minimum capacity to be maintained.

The limits given in Equation (1) define the change in capacity that is observed at different times and at different time intervals. Therefore, Equation (1) can be defined for monitoring different parameters like temperature, network life time and amount of battery consumed. Therefore, Equation (1) can be modified as,

$$b(i) = \frac{b(i - i_o)}{C_n} \tag{2}$$

where,

$b(i - i_o)$ represents the variation of current to nominal charging capacity.

To know exact status of loss in electric vehicles the ratio in Equation (2) should be calculated. This is done to prevent the self-discharge that happens inside the electric vehicles. If any count at the output changes then an alert will be sent to the particular user who is operating the vehicle because this self-discharge can cause severe damage to the user who is operating the vehicle. Therefore, to avoid such damage the operating voltages should be known to the user and this timing operation can also be monitored using Things Speak by implementing Equation (3).

$$V_i = \frac{V_{dc} - V_{max}}{V_{min}} \tag{3}$$

where,

V_{dc} represents the input voltage which is converted to 5 V with the help of the voltage converter at the input side

V_{max} and V_{min} represents the maximum and minimum voltage that is attained at the output.

For safe operation the level of voltage should not exceed 0.5 V. Thus minimum voltage should always be within 4 V. If any discharge occurs at the battery then it should be immediately noticed and the changes will be intimated to the control station for providing necessary solutions. In case the users are charging their vehicles at home then the following constraint must be satisfied.

$$\sum_{i=1}^{n} V_{max}(vehicle, others) < V_{dc} \tag{4}$$

Equation (4) denotes that the maximum voltage supplied to the vehicle and other electrical equipment should be less than 230 V. In case the battery of the vehicle is charging at 230 V then it is very difficult to switch on other utilizations, therefore maximum voltage supplied to the vehicle can be reduced to 120 V. This limit will be ensured for safe operation of vehicles and it will not disturb the voltage that is supplied to other electrical machines. In case the user is charging at stations, where exact smart charging stations are will be informed to the user and available power at each station will be displayed using the

Things Speak monitoring system. The maximum power at smart charging stations can be calculated as the sum of three terms as given in Equation (5).

$$P_i(t) = P_i(s_t) + P_i(w_t) + P_i(g_t) \tag{5}$$

where,

$P_i(s_t, w_t, g_t)$ denotes the available power at the charging station using either solar, wind or available grid power that is supplied as per direction standard.

It is necessary to implement Equation (5) because in cities if more electric vehicles are operating at same time then, more charging stations are required and maximum power in charging stations should be displayed so that the user can visit the available charging station for charging the battery cells. After charging the battery accurate distance of travel should be monitored for safe driving. This travelling distance can be calculated using Equation (6).

$$d_i = \min \sum_{i=1}^{n} r_i \times b(i) \tag{6}$$

where,

r_i denotes minimum range that is estimated when the batteries are installed.

Equation (6) indicates that estimated range with a product of proportional capacity should be determined for providing maximum distance. If maximum distance is obtained then the total cost of installation with IoT technologies should be tested using Equation (7).

$$Cost_i = \min \sum_{i=1}^{n} (d_i \times e_i(t)) + S(i) \tag{7}$$

where,

$e_i(t)$ represents the variation of energy with respect to time.

It is observed that Equation (7) is distinctive and it is not calculated in other existing literatures. In all existing methods only the cost of battery charging is calculated, whereas in the proposed model, total cost which includes battery charging and sensor installation is calculated and it is also minimized. For saving more energy the temperature consumed by electric vehicles should be much lesser. Therefore, if a high temperature is observed then the user should be intimated and engine of vehicle should be switched off for certain period of time. This can be formulated as given in Equation (8).

$$temp(i) = V_{\max}(t)^l \times d_i \tag{8}$$

where,

l denotes the constant value and it depends on the type of installed battery. For all battery types the constant can be varied between 1 and 1.08.

The temperature value which is calculated from Equation (8) is a function of both input voltage and range of travel. If the engine is very hot and at that time maximum voltage is supplied, then it will cause failure in both the electric and electronic components that are installed all over the body of the vehicles. Therefore, to avoid such incidents the temperature should be maintained within an average value. The above parameters (Equations (1)–(8)) can be modeled as an objective function of the proposed work as denoted in Equation (9).

$$O(i) = \min \sum_{i=1}^{n} temp(i), Cost_i, \max \sum_{i=1}^{n} b(i), C_i \tag{9}$$

If the objective function in Equation (9) is satisfied then efficiency of electric vehicles will be much higher at reduced cost.

3. Optimization Algorithm

For the proposed model there is a need for integrating the optimization algorithm to monitor the range of electric vehicle so that automatically the performance of battery will be calculated. During the IoT process this optimization algorithm is much important because it is very helpful for data collection and the aggregation process. Additionally, if an efficient algorithm is integrated then data will be sent from source to destination within a short period of time. Therefore, an efficient machine learning algorithm [29] is chosen for integrating with objective function. There are different types of machine learning algorithm and in the projected work one type of decision tree algorithm which is denoted as Extended Gradient Boosting Algorithm (EGBA) is incorporated. There are many optimization algorithms that are involved in calculating the charges of electric vehicles but EGBA is preferred due to the underlying principle for selecting the precise solution by combining it with previous state outputs. In the proposed method for all case studies the values will be predicted based on past values and it will be stored in central data base. If an individual needs authorization for accessing the data then it is possible to access only if the previous values are known. In addition, the prediction speed of EGBA is much higher than other machine learning algorithms and in the proposed method there is a high probability of error in each stage due to the existence of different solutions.

Therefore to reduce the prediction error at the output of each stage, EGBA is much preferred compared to other algorithms. Even if a small change occurs during prediction process then errors will be corrected using nominal charge capacity as given in Equation (2). Moreover, EGBA has the ability to make the predicted values be closer than target values by reducing the inaccuracy in the charging process (voltage sets). The reason behind choosing this decision tree algorithm is that for all electric vehicles different solutions will be considered and finally the best parametric value will be sent to the users. In this case EGBA is chosen for boosting the data efficiency with much less memory space. Additionally, the integrated algorithm can also process large data with a parallel data collection process. Besides these advantages, during transfer of parallel data more correlation will occur and EGBA will overcome this correlation. Input variables will be calculated as shown in Equation (10).

$$Z_i = \sum_{i=1}^{n} \frac{Z_i(t_i)}{x_i} \tag{10}$$

where,

Z_i denotes the number of structures in a single tree which varies with respect to time t_i;

x_i represents number of users where the data are processing.

From Equation (10), Z_i can be calculated using the following,

$$Z_i(t_i) = \sum_{i=1}^{n-1} r_i \tag{11}$$

where,

r_i denotes the reduction value that is obtained in a circle (either 0 or 1).

The essentials of EGBA start by implementing a collaborative model for overcoming the loss that is obtained at an earlier stage. This model can be formulated by using two terms as given in Equation (12).

$$y_i = \sum_{i=1}^{n} \sigma_i h(i) \tag{12}$$

where,

$h(i)$ is used to compensate the loss produced by y_i at each output stage.

In the next stage an equivalent decision tree should be added with residuals as indicated in Equation (12). In case if the output is not satisfied in any stage then next leaf can be formed and the output of next stage will be treated as the best optimal value if the user is satisfied. This provides the maximum advantage to all users during the data aggregation process. Thus, the process can be extended as shown in Equation (13).

$$(Z_1(y_1 - h_1)), (Z_2(y_2 - h_2)), \ldots\ldots\ldots\ \ldots\ldots (Z_i(y_{1\backslash i} - h_i)) \tag{13}$$

If Equation (13) is implemented then a better data model is guaranteed at both the transmitter and receiver side. Even at the receiver side some correlation will occur and it is detected using the probability test as given in Equation (14).

$$p(n) = \frac{|r|\sqrt{N-1}}{1-|r|} \tag{14}$$

where,

$|r|$ represents the correlation value between the limits 0.3 and 0.8.

If the correlation value is lesser than 0.5 then optimal values will be obtained and if the value exceeds 0.8 then worst value will be obtained and more iteration and trees are required for getting the best values. Mostly when EGBA is integrated, then optimal values will be obtained within a lesser number of iterations and the loss function will also be reduced. The flow chart of optimization process is elaborated in Figure 1.

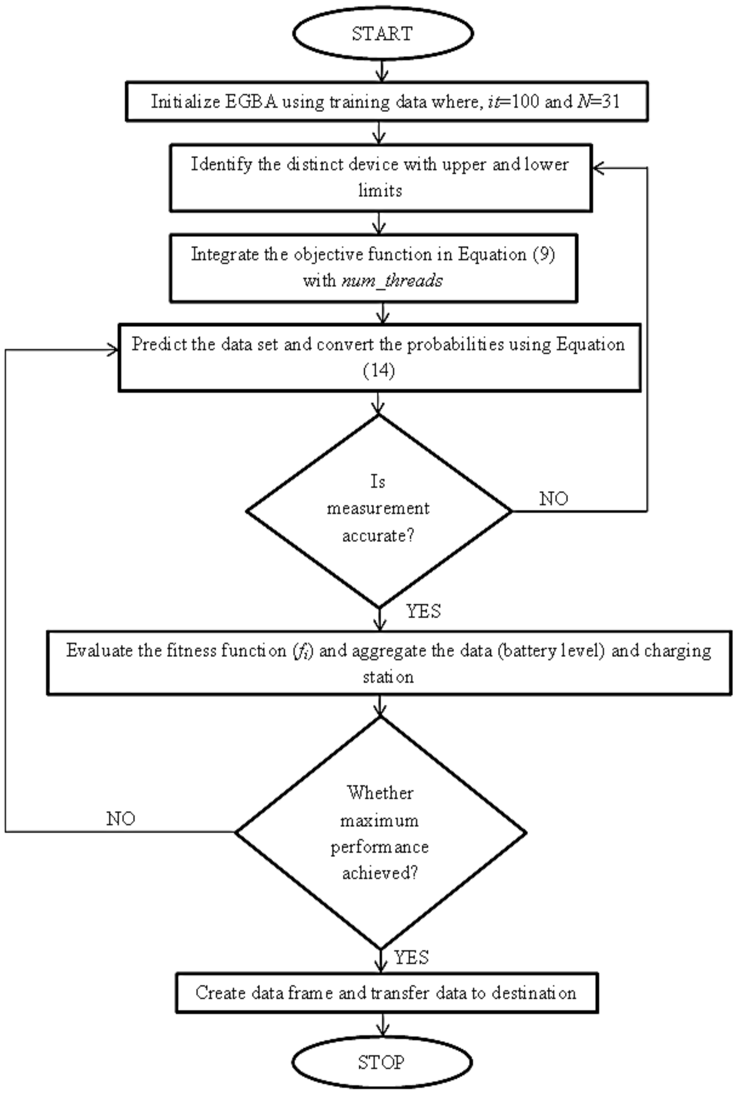

Figure 1. Flow chart of Extended Gradient Boosting Algorithm (EGBA).

4. Results and Discussion

The proposed formulation on electric vehicles using IOT with EGBA has been monitored using Thing Speak, an online monitoring system. For offline analysis the results monitored in Thing Speak are visualized using MATLAB for conserving exact consequences in day-to-day analysis. To analyze real time implications and for introducing electric vehicles with IoT in industry a real time battery test was performed as shown in Table 1 and it was analyzed with four different scenarios. The purpose of choosing Thing Speak is that it was more suitable for commercial projects where high MATLAB calculations were important. The proposed method provided more profit to users and for observing the output offline Think Speak was better than other services. Additionally, the authors had multiple user accounts in Math Works and one complete unit of Think Speak with a license. Therefore 33 million messages could be stored and information could be updated for periods of 15 s because it was essential to observe the amount of charges that were passing inside the vehicle. If differences in charges were observed within a short span of time then state of charging information could not be retrieved. Thus the time of interval should be between 10–15 s and it could also be changed manually (even to 1 s) in each unit for licensed users. In the proposed measurements using Ardunio UNO for increasing the efficiency and to optimize the cost of operation angle sensors was used thus minimizing the loss of energy consumption. In addition, an HVAC (Heating Ventilation and Air Conditioning) actuator sensor was installed for providing proper air flow to the entire system and to achieve low hysteresis loss. Additionally, for checking the entire control unit in the engine, pedal sensors was integrated thus sensing the minimum and maximum throttle values. In Arduino UNO a battery was connected to one side of the voltage divider where a 9V battery was connected using a serial port at high baud rate. Then a Wi-Fi shield was connected for connecting microcontroller in Arduino unit using ESP 8266 node MCU for receiving sufficient input power where the state of charge that was present in the battery was communicated with the Android module for the transmission process. After activating the Wi-Fi module Arduino UNO sensed the level of charge and other required parameters for uploading in Thing Speak.

Table 1. Average real time battery test for different vehicles.

Parameters	Battery Type for Real Test Drive			
	Li-Ion	Na-NiCl_2	Ni-MH	Li-S
Consumption of electricity (kW/h)	15.6	13.5	16.2	12.4
Self-sufficiency	146	153	138	193
Input energy (kJ)	9546	8692	7854	8235
Output energy (kJ)	193	182	169	165

Table 1 compares the different types of batteries with considered parameters like electricity consumption, self-sufficiency, input and output energies. It can be seen that Li-S performed well in all parametric conditions where electricity consumption was lesser with high self-sufficiency. Since the batteries were imminent with reduction in low power cases it was the best suitable solution for electric vehicle charging when compared to other battery types. In the proposed method one unit of channel was purchased and in that package one battery with a charger system was connected for replacing the internal combustion engine. In addition the hardware component was Arduino UNO where the entire charging system was converted from AC to DC. Additionally, a stationary restraint which was integrated at all charging stations had a cylindrical or round shaped connector and it depended on the type of protocol that was selected at corresponding stations. It was also possible to have multiple connectors if the number of channel was higher. If inlets were connected inside the vehicle then there was a possibility that in the channel either AC or DC could be selected or the mode of charging was also carefully chosen.

The type of batteries that are preferred for electric vehicle is Lithium Sulfur (Li-S) because it will increase the theoretical charging capacity with weightage of 1672 mAh/kg and it will be a desired rechargeable solution for charging electric vehicles with high density. In order to determine whether 1 phase or 3 phase current charges are used the type of cables should be pre-determined. If the charging stations are using single cables then one phase will be preferred and in case three cables are present then channels will be changed and three phases will be given. In addition the batteries will be installed for supporting both single as well as three phase connections.

In the proposed method users should send command to each charging station for requesting their vehicles to charge because sometimes charging stations may be highly congested and there will a possibility that users cannot catch a period for charging. In addition when users are charging their vehicles they should be able to control the charges within a particular state. Therefore in these two relevant cases there is a need for pilot signals to be generated at the receiver side. Therefore, a pilot signal will be generated on request and these pilot signals will be observed using a pilot signal monitor which is integrated with Arduino UNO, since in the hardware portion Arduino UNO is implemented software and constituents play a vital role in charging electric vehicles imperative to its operation. Moreover Arduino IDE will be used for programming the entire vehicle by integrating the sensor components. Therefore, for better perception of Ardunio UNO, Thing Speak will be used for observing the signals at receiver.

Since the proposed method was analyzed with the help of an IoT-based management system it was necessary to have a smartphone at the user end to observe the output using Thing Speak. In addition, more information was provided in terms of sensors that were installed in vehicles in content of several features like charging time, path of travelling, state of charge with user ID, internal temperature and speed of vehicle. The format of data processing was integrated at the user end for simplifying the components by determining all relevant information including the area of travel. The correct indication of the data processing technique consisted of time, which was calculated in milliseconds with type of channel indication. After selecting the channel type the format of data was designated; this was followed by a cyclic code that was used for denoting the charge in vehicles. Once the cyclic codes were generated then a new header was introduced at the user end which denoted the data source. The quantity of data was limited based on the type of database where Thing Speak could store eight different channels where one unit could store 33 million messages. The time of interval for storing the data was 15 s but mean value of measurement in data was updated every second as the value of electrical quantity was changing within a short interval of time. The measured data was first displayed on the screen then it was checked for errors. Once the errors were checked then automatically data was stored at the back end for further usage after 15 s and even the time period of data storing could be reduced to 1 s due to manual operative tools. Additionally, from Figure 2 it can be seen that all n values for different sensors were combined at the output thus providing one precise value in each channel.

EGBA was primarily introduced for reducing the prediction error because the data were only predicted in case users were high. Suppose the data source given in Table 2 was fed directly from past available data, then Thing Speak would compare both the data and after data evaluation predication error would be reduced. Thus if input data was provided appropriately then error would be reduced which in turn increased the accuracy of EGBA.

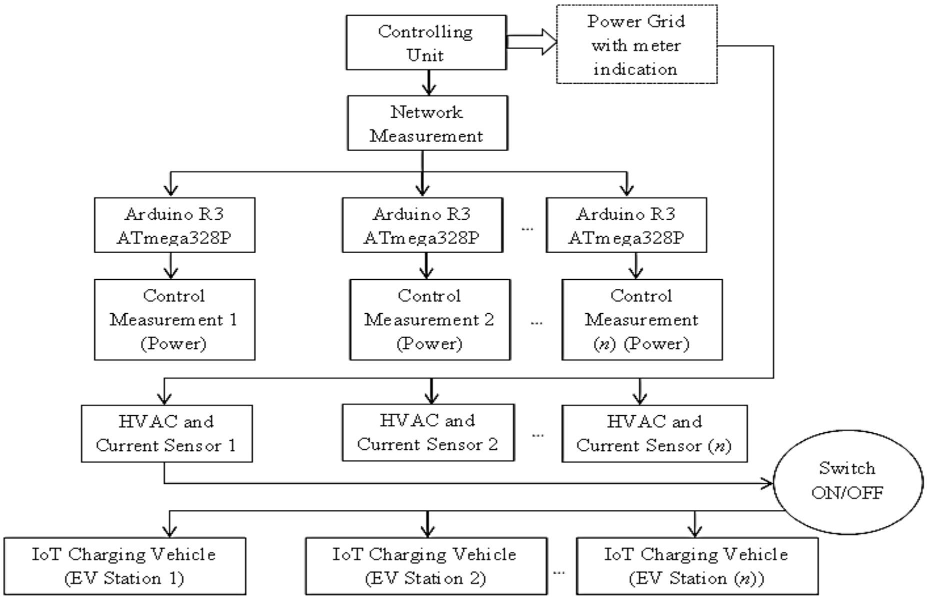

Figure 2. System architecture and wiring connection of proposed method.

Table 2. Data source of Electric-vehicle.

Features	Data Source	Thing Speak	GMap
Directions	Nearest Location of charging station	Y	Y
Travel path	Shortest path for travel	Y	Y
Charging time	Limits of charging	Y	N
State of charge	Health of battery	Y	N
Charging ID	Identification of battery type	Y	N
Enclosed Temperature	Limits of Temperature	Y	N
Speed	Acceleration	Y	N

4.1. Scenario 1—Analysis of Capacity

In this scenario the most important parameter for operating electric vehicles which was denoted as capacity was monitored (online), simulated (offline) and discussed. The capacity of battery changed from engine start time to complete running time and the main objective was to achieve high capacity on more successive time. Therefore, for exact analysis the electric vehicle was started at 8 AM with a maximum capacity of 30 kW/h and the test vehicle was kept running until it reached minimum capacity level. The vehicle was kept working for a period of 10 h and it was observed that level of capacity was monitored perfectly and it was found that for proposed method the level of capacity was reduced slowly and it operated for more time when compared with existing methods [4,6]. The results are visualized in MATLAB and are shown in Figure 3.

From Figure 3 it can be seen that at starting time (8:00 AM) the capacity was 30 kW/h and for a period of 2 hours the capacity was decreased to 26 kW/h and finally after 10 h it reached to 12 Kw/h. However, for existing methods [4] after 2 hours the capacity was reduced to 24 kW/h and after 10 h it reached 5 Kw/h. Similarly, for Reference [6] after 2 hours the capacity was reduced to 25 kW/h and after a certain gap it reached 8 Kw/hr. However, the existing values were not predicted exactly due to the absence of sensing devices and data transfer via internet. Additionally, it was not possible that capacity level was reduced to 5 kW/h with the same energy on battery. This proves the importance of IoT devices in electric vehicles and when capacity reaches a minimum level (12 kW/h). Then an alert message will be sent to the user and all data will be aggregated at the receiver end.

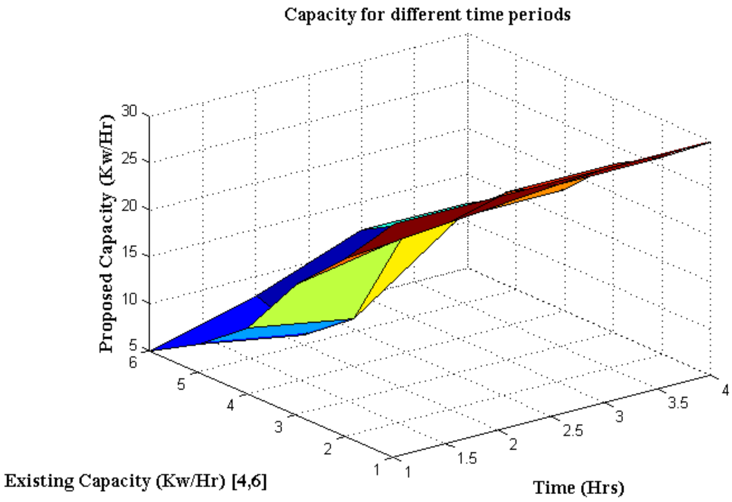

Figure 3. Estimation of capacity for different time periods.

4.2. Scenario 2—Design of Voltage Sets

Once capacity was calculated in Scenario 1 then using both capacity level at output and minimum capacity level the state of charge from Equation (1) was calculated. The voltage levels were maintained with the minimum and maximum limit between 600 to 1500 V respectively. It was observed that state of charge for proposed method increased and it was equal to the maximum level as prescribed by different organizations. Since the maximum capacity was obtained in the proposed method the state of charge automatically increased and was compared with the existing method [4,6]. The results for this scenario are visualized and displayed in Figure 4.

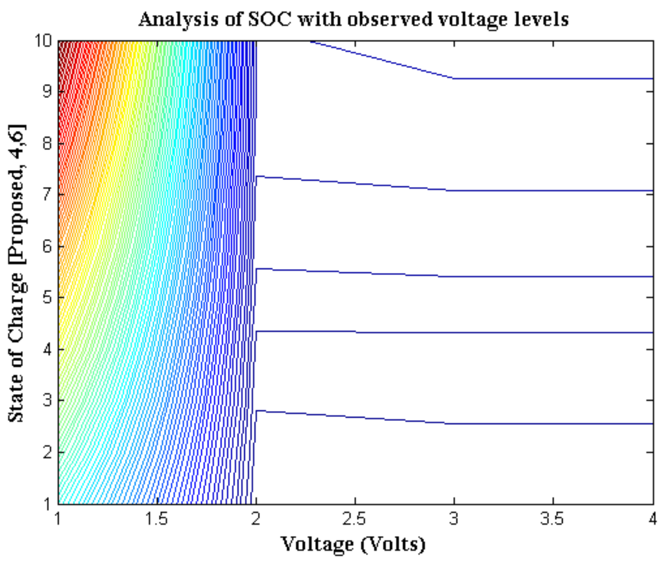

Figure 4. State of charge for consistent voltage levels.

From Figure 4 it can be seen that for voltage level of 800 V the state of charge was 34 VDC (DC voltage (V_{DC})), whereas for existing methods [4,6] it is much less and was equal to 27 and 30 VDC respectively. This proved that for the proposed method the voltage level of battery was monitored precisely and even if the voltage was much lesser then an alert would be indicated during the start of each vehicle and the users could charge it on their own and they could ride it for few kilometers before they reached nearby charging stations.

4.3. Scenario 3—Measurement on Range

After analyzing the corresponding voltage levels which varies with time, then distance of travelling in electric vehicle was analyzed. During this scenario range was analyzed for the same 10 h starting from 8 AM. It was observed that range covered by electric vehicles in the proposed method was much higher than the existing method [4,6]. For example the vehicle engine started at 8 AM and when it travelled for 2 hours the range covered was 40 km whereas with same speed the existing method [4,6] was able to achieve only 32 and 34 km respectively. The same reason was followed in this scenario, where it was not possible to travel more range with the same battery capacity but due to absence of IoT-based technology the readings were taken erroneously.

If this imperfect reading was fed to all users, then they would not come forward to buy electric vehicles as the range was much lesser. However, when IoT was integrated with electric vehicles, then the exact range could also be measured directly by users and this provided consummation for all users in real time. Even after 10 h it was observed that the range covered was much higher and with the existing methods [4,6] is much less as long as time increased. The exact range calculation is visualized and is shown in Figure 5.

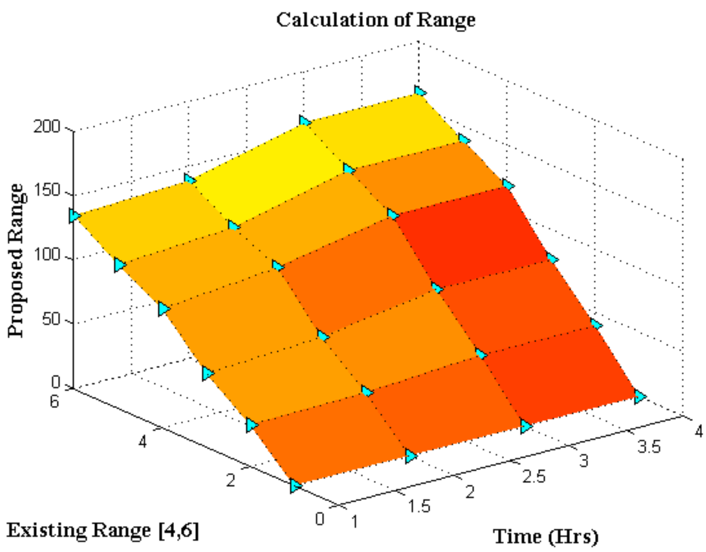

Figure 5. Drifting ranges for different interval.

4.4. Scenario 4—Expanse of Temperature

It is very important to analyze the effect of temperature in electric vehicles because if the level of temperature is higher than the recommended level then all electric and electronic components will be damaged. Therefore, if engine heat goes beyond certain temperature, then an alert will be sent to user for switching off the engine. Thus, this scenario was tested using both speed of vehicle and voltage level in battery which rose from minimum to maximum. For example if the speed of the vehicle was 67 km/h, then the corresponding voltage level should be 1200 V and the maximum temperature during this corresponding case was 65 degrees. However, the proposed method was able to maintain much lower temperature which was equal to 52 degrees but the existing method [9] produced a temperature which was equal to the maximum temperature. This indicated that engine should be switched off for a certain period of time.

Figure 6 shows the MATLAB visualization of Things Speak in offline mode where, the vehicle was tested for a maximum speed and voltage of 125 km/h and 1500 V respectively. Even during maximum speed at voltage the engine produced less heat and no alert was sent to the user. The experiment lasted for a period of 10 min and the vehicle travelled with a maximum temperature of 63 degrees only. Hence, this scenario proves the importance of monitoring temperature in electric vehicles using IoT processes.

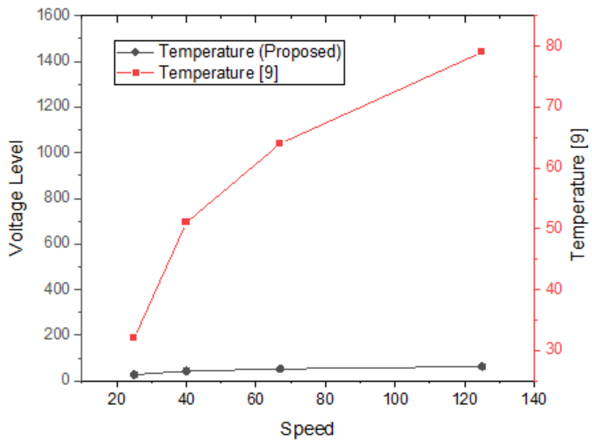

Figure 6. Reflection of temperature.

4.5. Scenario 5—Minimization of Cost

After evaluating all parameters it was important to calculate the cost of installing intelligent sensing device with electric vehicles. If all above parameters with some addition of minor parameters were monitored at low cost then automatically it added benefit to a user who purchased it.

Therefore the cost of implementation was calculated using Equation (7) and the values were simulated in MATLAB and shown in Figure 7. Figure 7 is simulated using values of distance, variation of energy and sensor installation, where the proposed method produced less cost when compared with existing literature [4,6]. To test the minimum cost of IoT process only sensor installation was considered and the making of all body parts in electric vehicles was not calculated. For experiment analysis the maximum number of nodes was given as eight and From Figure 7 it can be seen that for maximum voltage level of 1500 V the cost of proposed method was Rs. 4238, whereas for same setup the existing method [4,6] would need Rs. 4760 and 4532 respectively. This proved that the proposed method was also able to reduce cost of installation with maximization of distance and energy.

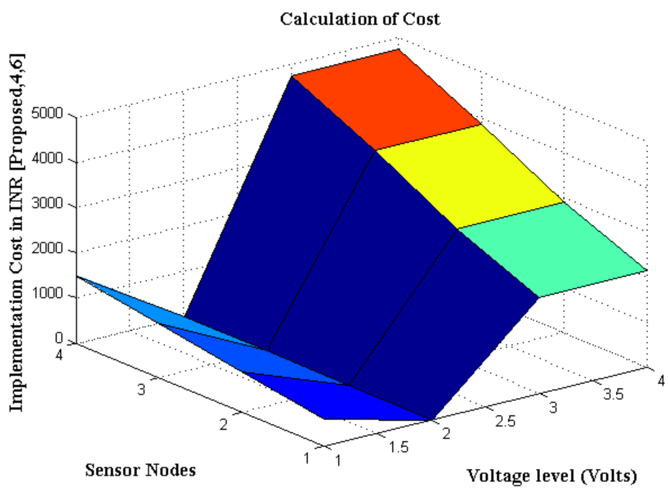

Figure 7. Calculation of cost for connected sensors.

5. Conclusions

In this article the monitoring technology of electric vehicles using IoT technology has been discussed. All important parameters like distance covered, cost and capacity of battery which are related to smooth function of electric vehicles have also been monitored. For real time monitoring and for predicting accurate values an online monitoring system has been used. This will allow all users to predict the battery and its capacity with distance and accurate speed for extended life at their remote locations. For faster monitoring and for improving accuracy a boosting algorithm (EGBA) has been incorporated and all values are visualized in MATLAB in offline mode. In addition, the location of charging station and the number of vehicles currently charging in near-by stations can also be displayed. Finally the data aggregation process will be much effective because of the incorporated boosting algorithm and all data will be processed correctly to all respective users. In the future, this technology can be extended by using cryptographic process where a car battery will be protected using 8 bit encrypted codes.

Author Contributions: Conceptualization, S.U., F.A., H.M., Y.T., and R.K.; methodology, S.U., H.M., Y.T. and R.K.; software, S.U., F.A., H.M., Y.T. and R.K.; validation, S.U., F.A., H.M., Y.T. and R.K.; formal analysis, S.U., H.M., Y.T. and R.K.; investigation, S.U., H.M., Y.T. and R.K.; resources, S.U., H.M., Y.T. and R.K.; data curation, S.U., F.A., H.M., Y.T. and R.K.; writing—original draft preparation, S.U., H.M., Y.T. and R.K.; writing—review and editing, S.U., H.M., Y.T. and R.K.; visualization, S.U., F.A., H.M., Y.T. and R.K.; supervision, S.U., F.A., H.M., Y.T. and R.K.; project administration, S.U.; funding acquisition, H.M., F.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research is funded under Fast-track research funding program by Deanship of Scientific Research, Princess Nourah bint Abdulrahman University, Riyadh Saudi Arabia.

Acknowledgments: This research was funded by the Deanship of Scientific Research at Princess Nourah bint Abdulrahman University through the Fast-track research funding program.

Conflicts of Interest: The authors declare no conflict of interest.

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