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BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLE USING ARTIFICIAL INTELLIGENCE AND IOT TECHNOLOGY

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SUMMARY

With the rapid advancement in electric vehicle (EV) technology, efficient battery management has become crucial for enhancing performance, safety, and longevity. This research integrates Internet of Things (IoT) and artificial intelligence (AI) technology to provide a revolutionary solution to battery management in electric vehicles. Our suggested method uses IoT sensors integrated inside the EV battery to gather data in real-time while keeping an eye on many factors like voltage, temperature, and current. The system can learn from past data and adjust to changing situations thanks to the integration of AI, which increases forecast accuracy and battery management efficiency. By continuously analyzing data and adjusting parameters in real-time, the system enhances battery performance, extends lifespan, and ensures safety by identifying potential issues before they escalate. This data is then processed using a neural network-based algorithm to predict battery health, optimize charging protocols, and forecast remaining useful life. Battery parameters such as temperature, voltage, and current are collected from the sensors, such as temperature sensor, current sensor, and voltage sensor. These values are updated to the ESP 32 controller and the IOT (Internet of Things) cloud as thing speak. The battery parameters are stored in the Raspberry Pi controller. The support vector machine (SVM) will analyse the battery parameters to produce a better output. The SVM produced accuracy, precision, recall and F1-score of 90%, 80%, 78%, and 81%, respectively.

Key words*: battery, voltage, current and temperature, SVM, IoT.*

INTRODUCTION

The globe has been impacted by air pollution, global warming, and the unpredictability of traditional fossil fuels throughout the last three decades. The fact that fossil fuels remain the primary energy source for the global transportation sector helps to explain this. Approximately 70% of the 30% worldwide carbon dioxide emissions from the transportation industry are attributed to road-based vehicles, per a study conducted by the International Energy Agency (IEA). The primary reasons of the depletion of subsurface fossil fuel reserves are the transportation sector's excessive use of fossil fuels and the pollutants that arise from this use [1].

To ensure passenger security, the automotive industry has worked hard to develop trustworthy and efficient systems [28]. However, the air pollution in cities has increased along with the number of cars. Around 27% of greenhouse gas emissions are attributed to the transportation sector, with car transportation responsible for over 70% of these emissions, according to figures from the European Union [3].

Because of their capacity to lower greenhouse gas emissions and address global warming concerns, electric vehicles (EVs) have become more well-liked and acknowledged as a solution to these emissions challenges [29]. Electric vehicles (EVs) have supplanted fossil fuel-powered cars and have produced improved performance in terms of dependability, accuracy, and simplicity [10].

BMSs are essential for safe operation due to the rising demand for batteries from the growing popularity of smart grids and electric automobiles. However, onboard chips' constrained memory and processing power make this difficult. Machine learning is becoming crucial for identifying patterns in massive amounts of data, and cloud computing provides a flexible substitute for conventional techniques. Cloud-based AI-enhanced models will be used in BMS to improve modelling and prediction capabilities [5].

The automotive industry's transition from conventional to hybrid and electric vehicles depends heavily on (Li-ion). The BMS is crucial for EVs, and it may be challenging to accurately assess battery characteristics, such as SOH and SOC. The higher discharge prediction performance of random forests demonstrates how AI techniques can improve electric vehicle performance [7].

The necessity for electric cars (EVs) to replace internal combustion engines (ICE) and the growing awareness of climate change worldwide. Reviewing battery management systems, charging techniques, and power conversion technologies covers the elements and developments in electric vehicle technology [6]. It also covers cutting-edge technologies like IoT, AI, and ML to enhance EV performance. However, the continued usage of digital technologies means that cybersecurity issues still exist. Interoperability problems and possible preventative actions are also resolved [30], [31]. To improve household power usage and energy mix, a model for home energy management, or HEMS, must be used. It covers how energy storage, distributed generation systems, consumption devices, and electric car charging and discharging work. The HEMS can adapt to changes in tariffs and is self-regulatory. For scheduling and data storage, the framework uses a local information management terminal and advanced metering infrastructure (AMI) [9].

The invention of electric vehicles, such as motorbikes and bicycles, using AI and IoT technology. Using IoT logic, the device track’s location and speed and minimizes environmental damage using a smart charging method [32], [8].

The battery monitoring system typically monitors and detects changes in the battery, alerting the user through the car's battery indicator. Because of improvements in notification system design, manufacturers and customers may be informed about the battery's state via Internet of Things (IoT) technology. This is a maintenance support routine from the manufacturer. IoT uses internet connectivity in ways that exceed what is typically done with it. The ability to link various devices and everyday goods to the internet gives users access to the globe.

LITERATURE SURVEY

AIML are now included in the extension. Thanks to these cutting-edge ideas unique to BMS, it is now possible to more accurately predict battery performance, including its SOH, SOC and SOP [11].

A support vector regression technique, a traditional artificial intelligence algorithm, produces an exact battery model in the cloud after the Cyber-Physical System (CPS) is used to control battery management concerns. To address difficulties linked to battery ageing based on the battery model, battery deterioration quantification is finally carried out using the rain-flow cycle counting algorithm [36].

Support vector regression and the modified genetic algorithm control the EV thermal management system [2]. A double-population adaptive mutation approach and a state-of-the-art optimization procedure are used to construct modified genetic algorithm. The Auto-MPG and Computer Hardware data sets, which are used to modify the Support vector regression kernel function parameters, validate the accuracy of the method. [13].

QCNN uses input data from the driving segments that before and follow to estimate the battery temperature quantile. Quantile predictions yield a weighted total of the expenses of aging, depreciation, and battery cooling, which is used by the predictive control to set battery cooling limitations. In terms of cost weight tunability, input uncertainty resilience, and BTMS adaptation to various routes, the predictive BTMS has been evaluated [14].

The system implements a taken thermal model and a novel neural network as a thermal sub-model. A physics-based thermal battery system and a data-driven thermal battery model are directly compared within the same system. The accuracy of temperature estimation is evaluated between the models. Both models extremely accurately represent the temperature behaviour of new intelligent battery cells. However, the nonlinear autoregressive network with exogenous input-based data-driven neural network approach shows modest improvements in accuracy and computation time.

To enhance energy management in Electric Vehicles (E-Vehicles), real-time datasets with machine learning algorithms based on artificial intelligence can be used. The profile, shape, formulation, and essential constraints for the acceleration and deceleration needs may all be created for an electric vehicle [15] and a machine learning algorithm [16].

Simulation-based design optimization of the battery pack and battery management system is evolving and growing to incorporate state-of-the-art technologies like AI and ML to increase efficiency in design, manufacturing, and other processes. On occasion, they can be found in electric vehicles and energy storage devices. These novel BMS ideas, such the battery's SOC, State of Power (SOP), and SOH, may help predict battery performance more precisely.

The IoT tracks and collects battery data, which is subsequently analyzed. Battery data can be collected and analyzed on the cloud with Thing Speak. When working with batteries, the most important consideration is the SOC. Information on voltage, temperature, and current is needed to anticipate the SOC. It uses a DL model known as a Recurrent Neural Network to forecast the SoC of the battery. We may assess the efficacy of the RNN model by contrasting the observed and projected SoC [17], [4].

Electric vehicles store energy in lithium-ion batteries. These batteries do have several disadvantages, though, such as low efficiency at high and low temperatures, short electrode life at high temperatures, and safety issues with thermal runaway [12]. These issues immediately impact the dependability, performance, cost, and safety of the car. Batteries can overheat and ultimately explode because to electron mobility during chemical reactions that occur while charging and discharging at high temperatures. Thus, an efficient BTMS is one of the most crucial technologies for the long-term sustainability of electric cars. Modern batteries use their surface as a cooler to diffuse the heat generated while charging or discharging [18].

Electric vehicles (EVs) are seeing tremendous market expansion due to their efficiency and zero emissions. However, a battery's lifespan, cost, performance, and safety could all be impacted by other factors. Thus, battery management is required to improve a battery's performance under a range of operating conditions. One device that can regulate the behaviour of heated batteries is the battery thermal management system. Phase change material cooling systems, liquid cooling systems, air-cooling systems, and direct refrigerant cooling systems are among the BTMS technologies discussed in this article. We analyse the weights, sizes, prices, and capabilities of various systems [19].

Since Li-ion batteries outperform other types, they are the most often utilized kind in electric vehicles (EVs). The BMS, which is the core component of an electric car, may improve a battery's lifespan, safety, performance, and operation. One of the most crucial aspects of installing a BMS is assessing the condition of the Li-ion batteries, as it is necessary for the stable and secure functioning of batteries. Recently, researchers have concentrated on creating digital twin models utilizing ML approaches and cloud computing to automate and enhance the BMS state estimate process. [20].

Because of the enormous volume of battery data generated over its operating life, cloud computing has been embraced by the scientific community for data storage and analysis. This cloud-based digital solution offers a more flexible and effective option than more conventional approaches that could need significant hardware investments. Machine learning is rapidly becoming a key technique for gleaning insights and patterns from massive amounts of observational data. A cloud-based, AI-enhanced BMS is therefore expected to be created in the future [21].

BTMS employ PCM to regulate the battery's temperature and enhance performance with the help of an ANN. Investigating methods for comparing various battery heat management system types also seems beneficial given the rising use of AI in numerous industries. [22]. The BMS solutions, which call for a mix of hardware and software, include battery status estimates, fault detection, monitoring, and control responsibilities. This research extensively analyses the most recent machine-learning techniques for BMS. It distinguishes various methods according to their principles, types, structures, and ways of evaluating performance [23].

Businesses may construct and test whole buildings and complete assembly processes by constructing digital twins of their goods and manufacturing processes. This accelerates the transition to high-volume production while maintaining the quality of the end product. The hardest aspect of driving an electric vehicle is managing the battery. [24] investigates the types, architectures, underlying theories, and performance evaluations of the most modern machine learning approaches for battery management systems in high-power applications, such smart grids and electric vehicles [25].

Convolutional Neural Networks (CNNs) are employed in battery temperature predictive control models to forecast temperature changes over a specified prediction horizon. Adding forecast and historical data to the model greatly improves its accuracy and applicability. For median temperature estimations, the best model outperformed the others, with a mean absolute error of 0.27 °C.

This model's ability to deliver accurate predictions across various contexts highlights its potential for broader applications in energy management, offering significant improvements in battery temperature regulation and overall system efficiency [26].

Battery Electric Vehicles (BEVs) that use hybrid battery technology combine high-power and high-energy battery packs to maximize performance. A cloud-based energy management method that makes use of the Deep Deterministic Policy Gradient algorithm is advised in order to improve safety, lower energy loss, and save aging costs. This method reduces training epochs by 20.0% and 98.5% compared to typical Deep Q-Learning methods, and it also greatly minimizes energy waste and aging expenses [27].

PROPOSED METHODOLOGY

Key battery metrics including voltage, current, and temperature are monitored by the suggested battery management system using artificial intelligence and the Internet of Things. These parameters are measured using sensors and are updated in real-time by an ESP32 and Raspberry Pi controller. The system utilizes the Thing Speak cloud platform to aggregate and analyse the data, and it employs a Support Vector Machine learning algorithm to enhance predictive accuracy and decision-making, which is shown in Figure 1.

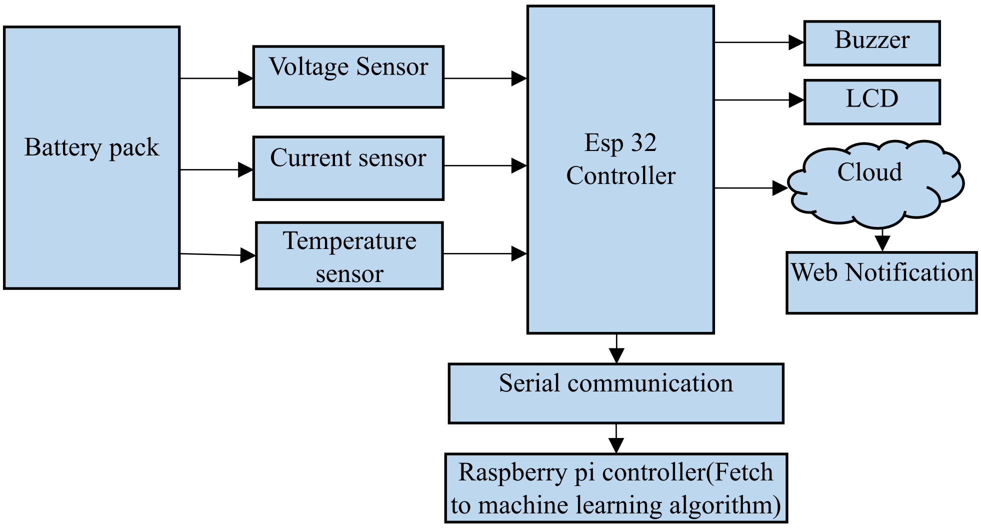

Figure 1. Overall flow diagram of battery and thermal management system

IOT Monitoring on BMS

Internet of Things-based battery pack monitoring is used to track and manage the battery pack specified in the suggested battery management system. IOT technology tracks battery health via sensors, controllers, and online apps. Sensors that detect temperature, voltage, and current are used to get these readings. The voltage and current sensors continually check the battery's voltage and current, respectively. The voltage and current sensors can detect currents up to 5A and voltages up to 25V DC. To assess the battery's performance, the temperature sensor will keep an eye on its temperature. After processing the sensor data, the controller shows the results on the LCD.The ESP 32 controller collects the temperature, voltage and current values. These values are updated to the IoT cloud.

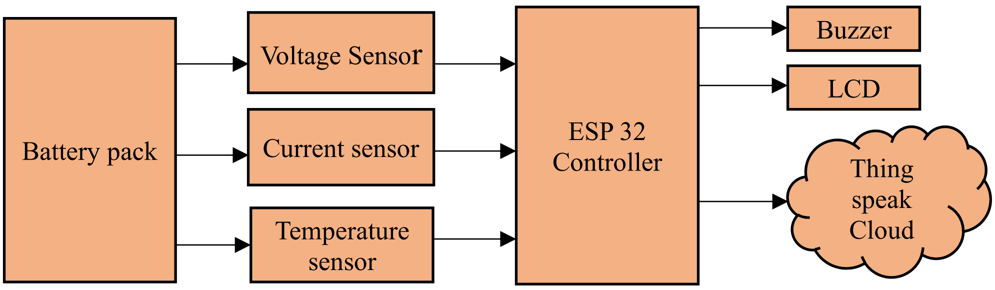

Figure 2. IoT monitoring of BMS

A microprocessor with Bluetooth and Wi-Fi integrated in is called the ESP 32 controller. It activates a 5-volt power source. Electric vehicles are the primary users of lithium-ion batteries. The AC and DC currents are measured by the ACS712 current sensor. Low current and high or low voltage levels are measured by the voltage sensor. An electrical signal is utilized to measure temperature using a temperature sensor. The LCD shows the values for temperature, voltage, and current. When the temperature rose to a certain point, the 12 V buzzer went off. Additionally, Thing speak IoT cloud was updated (Figure 2).

Battery Management System Based on AI

For batteries and thermal management systems, among other hardware and software components, to work well, they must cooperate and be controlled. Among the parts of the BMS are a position machine, temperature monitors, a cut-off field-effect transistor, a cell voltage monitor, a cell voltage balance, and a real-time clock. There are several chips available nowadays that have PMS built in. The capabilities of freestanding, fully integrated systems can be matched by simple Analog front ends with microprocessors for monitoring and balancing. In various systems, functional components are placed differently. Compared to existing protection circuit designs, the proposed BMS includes more sensors, allowing for enhancements like precise alarms and controls to avoid overcharging, over discharge, and overheating. Battery factors such as cell temperature, current, and voltage must be monitored and evaluated using a sensor network. The battery parameters are monitored and stored in a Raspberry Pi controller, a minicomputer used for real-time implementation and to fetch Python software. The high-level programming language Python comes with a number of packages, including one for artificial intelligence.

Support Vector Machine (SVM)

To tackle both linear and nonlinear problems in the given classification task, support vector machines are developed. The foundation of support vector machine is the structural risk minimization concept, which uses the VC dimension parameter to control machine learning complexity and lower an upper constraint on projected risk.

When the test data are linearly separable, the key to using the SVM is to figure out how to solve the binary classification issue and identify a classification line that divides the data into two groups. The appropriate classification line is a straight line or plane when the data are two-dimensional or three-dimensional, and it is a linear hyperplane when the data are multidimensional.

Assuming that k is a training samplesx_i, y_i, where i=1 and each sample has l inputs ($x_i \varepsilon R^l$) with an output class label of$y_i \varepsilon - 1, 1$. The vector perpendicular to the hyperplane with constant b is called the vector W.

$$w.X + b = 0 \quad (1)$$

So, the classification function of the training data is explained below for Eq (2),

$$f(x) = sign(w.X + b) \quad (2)$$

As a result, the canonical hyperplane is defined as having a minimum distance of one unit between the data and the hyperplane.

Therefore,

$$y_i(X_i.w + b) \geq 1 \quad (3)$$

A hyperplane; All pairs $\{\lambda_w, \lambda_b\}$ describe the same hyperplane, but their functional distances to the data point differ. Par. (4), which normalizes the magnitude of w, gives the geometric distance.

$$\frac{y_i(X_i.w+b)}{\|w\|} \geq \frac{1}{\|w\|} \quad (4)$$

For a good generalization capability, the data point and the hyperplane should be as far apart geometrically as possible. The Lagrange multiplier minimizes the ||w|| to accomplish. Therefore, Eq. provides the depreciation (5).

$$W(\alpha) = -\sum \alpha i \; i=1 \; +1 \; 2 \; l \; i=1 \quad (5)$$

Here,

$$\sum_{i=1}^{l} y_i \alpha_i = 0 \quad (6)$$

$\alpha - vector\ of\ l\ non - negative\ Lagrange\ multipliers$

The quadratic programming problem to solve using Lagrange multipliers,

$$W(\alpha) = -\alpha^T l + \frac{1}{2}\alpha^T H\alpha \quad (7)$$

Then,

$\alpha^T y = 0 \quad 0 \leq \alpha_i \leq C,\ \ i = 1, 2, \ldots\ldots, n$

The optimal separating hyperplane is expressed below,

$$w = \sum_i \alpha_i y_i X_i \quad (8)$$

When the functional distance of the data point is greater than 1, $\alpha_i = 0$. Therefore, only the data points lying on the edge is$\alpha_i > 0$, This is the best hyperplane for separation. The weight of the data points that contribute to the hyperplane determines how αi is scaled. In order to calculate and convey both positive and negative SV,

$$b = -\frac{1}{2}(w.X^{+} + w.X^{-}) \quad (9)$$

A nonlinear decision boundary is produced in the input space by constructing a separating hyperplane in this feature space. In a high-dimensional space, costly dot product calculations can be omitted by using a kernel function.

The ideal separating hyperplane ought to be able to hypothetically separate every data point when the soft margin constant, C, is infinite. On the other hand, the classifier's finite C soft margin permits a trade-off between accurately categorizing all data and the hyperplane model's complexity.

If the data points are not linearly separated, they may be in the higher dimensional feature space. The data points are projected onto a higher dimensional space using the kernel technique.

Equation (10) illustrates that the kernel function K (Xi, Xj) defines the dot product in the higher dimensional feature space.

$$K(X_i, X_j) = \Phi(X_i).\Phi(X_j) \quad (10)$$

As a result, Eq. (11) represents the classification model with the kernel function implemented. This is suitable for use in determining the load pattern in this study (Figure 3).

$$f(x) = sign\ (\sum_i \alpha_i y_i \left(K(X_i, X_j)\right) + b) \quad (11)$$

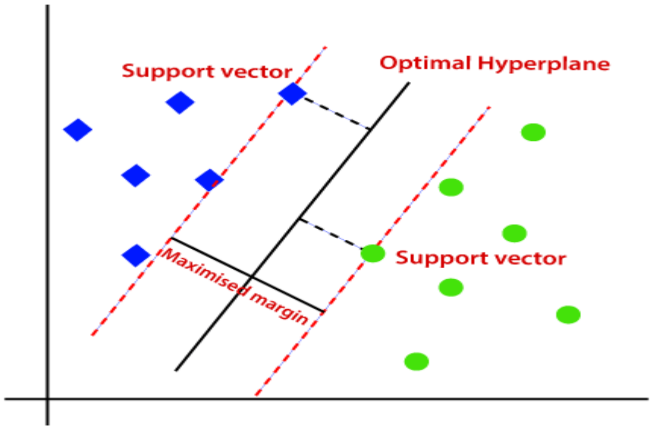

Figure 3. Support vector machine model

RESULT AND DISCUSSION

Battery management system based on AI and IoT technology to monitor the battery condition depending on voltage, current and temperature parameters. These parameters are monitored at any time in the Thing speak cloud with the help of an ESP 32 controller and sensors. Voltage and current parameters are collected from big data for analysis. The big data was analyzed in a Raspberry Pi controller with an SVM machine learning algorithm. The big data was analyzed and implemented in Python using the Thonny tool.

The voltage, current, and temperature sensors interface with the ESP32 microcontroller and the Raspberry Pi controller, forming a cohesive system powered by a battery pack. Jumper wires connect the sensors to the ESP32 for initial data acquisition and processing. At the same time, the ESP32 communicates this data to the Raspberry Pi via a suitable protocol such as UART, I2C, or SPI. The battery pack supplies power to the ESP32 and Raspberry Pi, ensuring that all components are properly energized. It is essential to establish a common ground across all devices to maintain stable operation and accurate data transmission, which is shown in Figure 4.

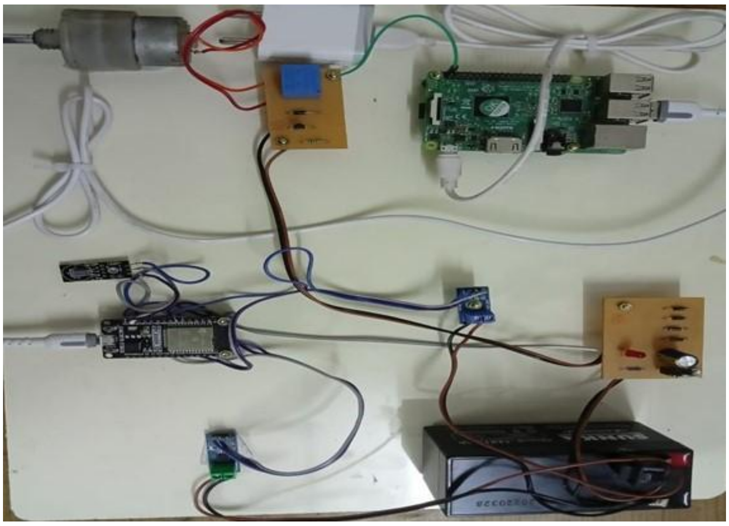

Figure 4. Hardware image of BMS

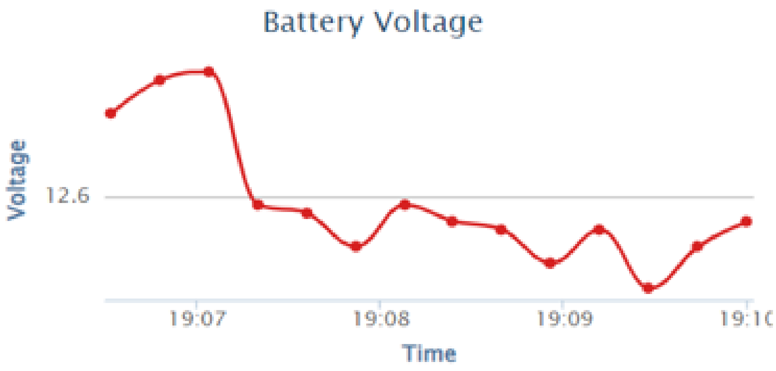

Figure 5. Estimation of voltage

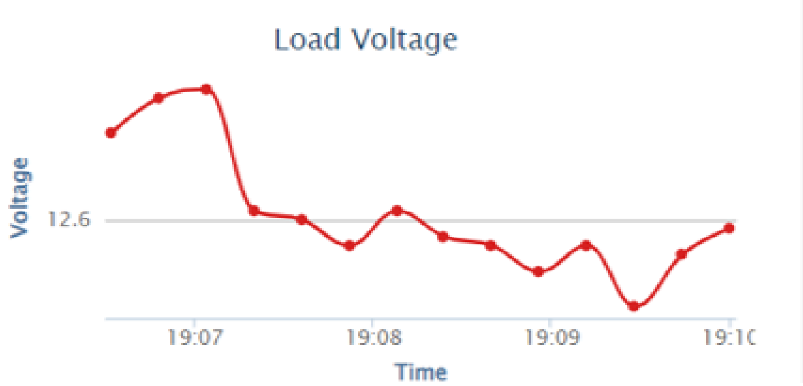

Figure 6. Estimation of load voltage

The voltage sensor senses the voltage value through an ESP controller. The controller updated to the Thing speak cloud. The current parameters vary depending on the battery charging and discharging conditions shown in Figure 5. And how much voltage is delivered to the load, which is shown in Figure 6.

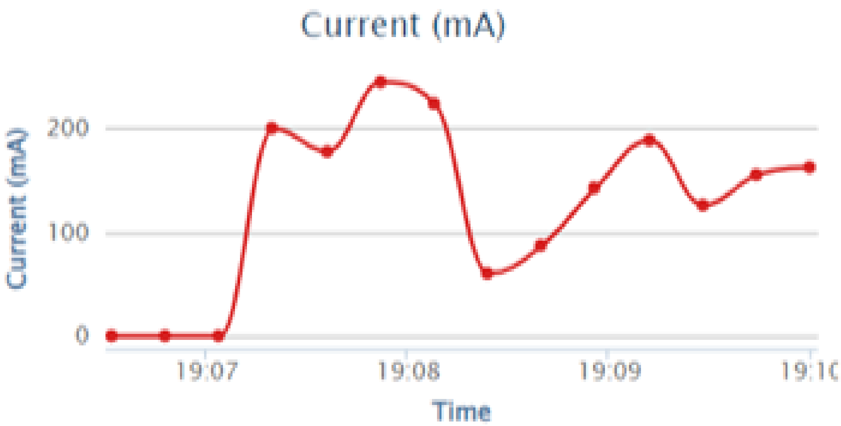

Figure 7. Estimation of current

The current sensor senses the current value through the ESP controller. Controller updated to Thingspeak Cloud. The voltage parameters vary depending on the battery charging and discharging state, as shown in Figure 7.

Figure 8. Battery temperature

The temp sensor senses the temperature value through the ESP controller. Controller updated to Thingspeak Cloud. The temperature parameters vary depending on the battery charging and discharging state, as shown in Figure 8.

The support vector machine analyzed the battery parameters with help of Raspberry Pi controller and Python software to produce the better result in Table 1.

Table 1: Analysis of support vector machine algorithm

Algorithm	Accuracy	Precision	Recall	F1 score
GRU	80%	73%	70%	72%
SVM	90%	80%	78%	81%

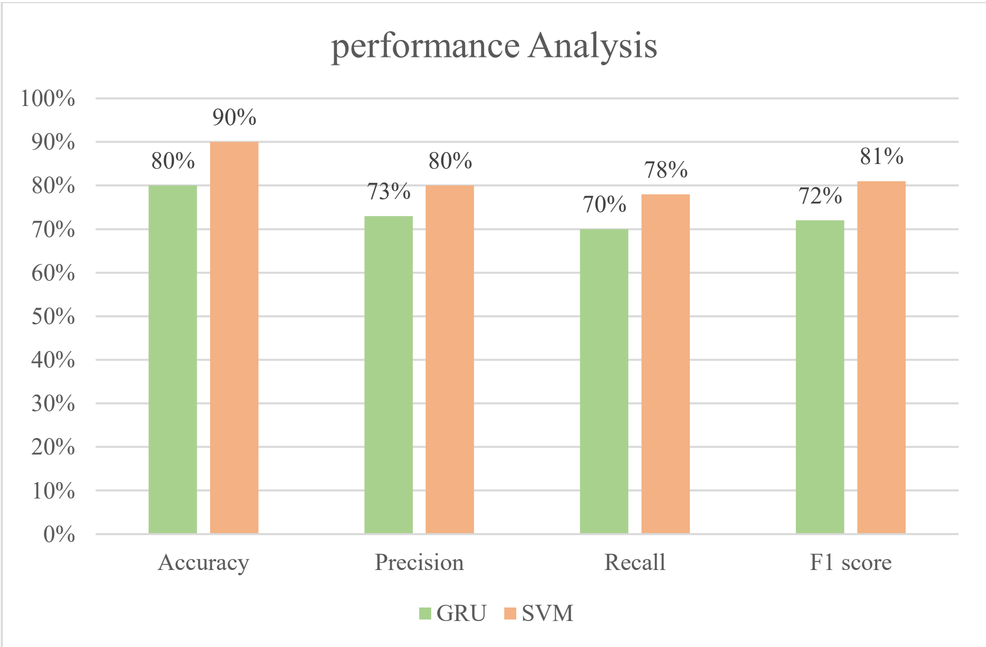

Figure 9. Evaluation of BMS using SVM

Figure 9 displays the f1-score, accuracy, precision, and recall obtained from the battery management system evaluation to analyse battery properties including voltage, current, and temperature data carried out in the support vector machine.

CONCLUSION

The BMS and AI technology discussed in this approach is used to find the battery parameters monitoring and report to the IoT application. As a result, a thorough view of the targeted IoT and AI technologies is done, emphasizing the problems. Lithium-ion batteries were the subject of this suggested study because of their higher power and energy densities, longer longevity, lower discharge rates, and increased efficiency. The essential elements and their functions in a battery management system's safe operation and operating cycle have also been defined in order to guarantee dependable and secure battery operation in electric vehicles. The battery system's temperature, voltage, and current must all be exact. Additionally, in order to get superior results of 90%, 80%, 78%, and 81%, respectively, the SVM algorithm defines the accuracy, precision, recall, and f1 score parameters.

REFERENCES

[1] Fayyazi M, Sardar P, Thomas SI, Daghigh R, Jamali A, Esch T, Kemper H, Langari R, Khayyam H. Artificial intelligence/machine learning in energy management systems, control, and optimization of hydrogen fuel cell vehicles. Sustainability. 2023 Mar 15;15(6):5249. https://doi.org/10.3390/su15065249

[2] Shwetha K, Shahar Banu S. Deep SVM-driven predictive analytics for improved decision-making in e-learning. Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications. 2025;16(2):564–78. http://doi.org/10.58346/JOWUA.2025.I2.034

[3] Abu SM, Hannan MA, Lipu MH, Mannan M, Ker PJ, Hossain MJ, Mahlia TI. State of the art of lithium-ion battery material potentials: An analytical evaluations, issues and future research directions. Journal of Cleaner Production. 2023 Mar 25; 394:136246. https://doi.org/10.1016/j.jclepro.2023.136246

[4] Tabatabaei SM, Khozeymehnezhad H, Akbarpour A, Varjavand P. Investigating Effects of obstacles Arrangement on the velocity of Density Current in experimental conditions. Journal of Science and Engineering. 2017;4(1):53-64.

[5] Xu Y, Zhang H, Yang Y, Zhang J, Yang F, Yan D, Yang H, Wang Y. Optimization of energy management strategy for extended range electric vehicles using multi-island genetic algorithm. Journal of Energy Storage. 2023 May 1; 61:106802. https://doi.org/10.1016/j.est.2023.106802

[6] Huy DT. The Risk Level of Viet Nam Commercial Electric Industry under Financial Leverage during and after the Global Crisis 2009-2011. International Academic Journal of Organizational Behavior and Human Resource Management. 2018;5(1):109-21. https://doi.org/10.9756/IAJOBHRM/V5I1/1810008

[7] Khawaja Y, Shankar N, Qiqieh I, Alzubi J, Alzubi O, Nallakaruppan MK, Padmanaban S. Battery management solutions for li-ion batteries based on artificial intelligence. Ain Shams Engineering Journal. 2023 Dec 1;14(12):102213. https://doi.org/10.1016/j.asej.2023.102213

[8] Farhan MN. Estimation of the production function of Diyala State Company for Electrical Industries for the period 2010–2019. International Academic Journal of Social Sciences.2022;9(1):1–8. http://doi.org/10.9756/IAJSS/V9I1/IAJSS0901.

[9] Ma Y, Chen X, Wang L, Yang J. Study on smart home energy management system based on artificial intelligence. Journal of Sensors. 2021;2021(1):9101453. https://doi.org/10.1155/2021/9101453

[10] Bhattacharya R, Kapoor T. Advancements in Power Electronics for Sustainable Energy Systems: A Study in the Periodic Series of Multidisciplinary Engineering. Smart Grid Integration. 2024:19-25.

[11] Ghalkhani M, Habibi S. Review of the Li-ion battery, thermal management, and AI-based battery management system for EV application. Energies. 2022 Dec 24;16(1):185. https://doi.org/10.3390/en16010185

[12] Zhang X, Rodriguez S. Advanced Optimization Techniques for Vehicle Dynamics in Robotics. Association Journal of Interdisciplinary Technics in Engineering Mechanics. 2023 Oct 9;1(1):1-3.

[13] Yan W, Li MJ, Mei N, Qu CY, Wang Y, Liu LP. Control strategy research of electric vehicle thermal management system based on MGA-SVR algorithm. Measurement and Control. 2023 May;56(5-6):1026-36. https://doi.org/10.1177/00202940221105851

[14] Billert AM, Erschen S, Frey M, Gauterin F. Predictive battery thermal management using quantile convolutional neural networks. Transportation Engineering. 2022 Dec 1; 10:100150. https://doi.org/10.1016/j.treng.2022.100150

[15] Mathankumar M, Gunapriya B, Guru RR, Singaravelan A, Sanjeevikumar P. AI and ML powered IoT applications for energy management in electric vehicles. Wireless Personal Communications. 2022 Sep;126(2):1223-39.

[16] Vidal C, Malysz P, Kollmeyer P, Emadi A. Machine learning applied to electrified vehicle battery state of charge and state of health estimation: State-of-the-art. Ieee Access. 2020 Mar 16; 8:52796-814. https://doi.org/10.1109/ACCESS.2020.2980961

[17] Umathe S, Hiware R. Artificial intelligence and IoT based smart battery management system for electric vehicle. In2022 International Conference on Smart Generation Computing, Communication and Networking (SMART GENCON) 2022 Dec 23 (pp. 1-7). IEEE. https://doi.org/10.1109/SMARTGENCON56628.2022.10083768

[18] Krishna G, Singh R, Gehlot A, Akram SV, Priyadarshi N, Twala B. Digital technology implementation in battery-management systems for sustainable energy storage: review, challenges, and recommendations. Electronics. 2022 Aug 27;11(17):2695. https://doi.org/10.3390/electronics11172695

[19] Buidin TI, Mariasiu F. Battery thermal management systems: Current status and design approach of cooling technologies. Energies. 2021 Aug 10;14(16):4879. https://doi.org/10.3390/en14164879

[20] Kleiner J, Stuckenberger M, Komsiyska L, Endisch C. Advanced monitoring and prediction of the thermal state of intelligent battery cells in electric vehicles by physics-based and data-driven modeling. Batteries. 2021 May 11;7(2):31. https://doi.org/10.3390/batteries7020031

[21] Kaleem MB, He W, Li H. Machine learning driven digital twin model of Li-ion batteries in electric vehicles: a review. Artificial Intelligence and Autonomous Systems. 2023 May 14;1(1):1-2. https://doi.org/10.55092/aias20230003

[22] Afzal MZ, Aurangzeb M, Iqbal S, Pushkarna M, Rehman AU, Kotb H, AboRas KM, Alshammari NF, Bajaj M, Bereznychenko V. A novel electric vehicle battery management system using an artificial neural network-based adaptive droop control theory. International Journal of Energy Research. 2023;2023(1):2581729. https://doi.org/10.1155/2023/2581729

[23] Shi D, Zhao J, Eze C, Wang Z, Wang J, Lian Y, Burke AF. Cloud-based artificial intelligence framework for battery management system. Energies. 2023 May 30;16(11):4403. https://doi.org/10.3390/en16114403

[24] Jaliliantabar F, Mamat R, Kumarasamy S. Prediction of lithium-ion battery temperature in different operating conditions equipped with passive battery thermal management system by artificial neural networks. Materials Today: Proceedings. 2022 Jan 1; 48:1796-804. https://doi.org/10.1016/j.matpr.2021.09.026

[25] Kumar VS, Begum AY, Moniruzzaman M, Sagar KV, Rao LM. Battery Management in Electrical Vehicles Using Machine Learning Techniques. Journal of Pharmaceutical Negative Results. 2022 Oct 7;13.

[26] Billert AM, Frey M, Gauterin F. A method of developing quantile convolutional neural networks for electric vehicle battery temperature prediction trained on cross-domain data. IEEE Open Journal of Intelligent Transportation Systems. 2022 May 23; 3:411-25. https://doi.org/10.1109/OJITS.2022.3177007

[27] Li W, Cui H, Nemeth T, Jansen J, Ünlübayir C, Wei Z, Feng X, Han X, Ouyang M, Dai H, Wei X. Cloud-based health-conscious energy management of hybrid battery systems in electric vehicles with deep reinforcement learning. Applied Energy. 2021 Jul 1; 293:116977. https://doi.org/10.1016/j.apenergy.2021.116977

[28] Lipu MH, Miah MS, Jamal T, Rahman T, Ansari S, Rahman MS, Ashique RH, Shihavuddin AS, Shakib MN. Artificial intelligence approaches for advanced battery management system in electric vehicle applications: A statistical analysis towards future research opportunities. Vehicles. 2023 Dec 25;6(1):22-70. https://doi.org/10.3390/vehicles6010002

[29] Wang Z, Jochem P, Yilmaz HÜ, Xu L. Integrating vehicle-to-grid technology into energy system models: Novel methods and their impact on greenhouse gas emissions. Journal of Industrial Ecology. 2022 Apr;26(2):392-405. https://doi.org/10.1111/jiec.13200

[30] Macharia VM, Garg VK, Kumar D. A review of electric vehicle technology: Architectures, battery technology and its management system, relevant standards, application of artificial intelligence, cyber security, and interoperability challenges. IET Electrical Systems in Transportation. 2023 Jun;13(2):e12083. https://doi.org/10.1049/els2.12083

[31] Jain R, Chakravarthi MK, Kumar PK, Hemakesavulu O, Ramirez-Asis E, Pelaez-Diaz G, Mahaveerakannan R. Internet of Things-based smart vehicles design of bio-inspired algorithms using artificial intelligence charging system. Nonlinear Engineering. 2022 Oct 26;11(1):582-9.

[32] Arya A, Arya M, Bhagat A, Paliwal P, Thakur T, Warudkar V. Artificial intelligence-based smart electric vehicle battery management system. Espacenet. 2021.