JITK (JURNAL ILMU PENGETAHUAN DAN TEKNOLOGI KOMPUTER)

VOL. 10. NO. 4 MAY 2025
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v10i4.6298

THE ROLE OF THE INTERNET OF THINGS (IOT) IN ELECTRIC VEHICLE MANAGEMENT AND MAINTENANCE

Callista Fabiola Candraningtyas[1]; Fikri Arkan Maulana[2]; Sapta Suhardono[3*]

Environmental Science Study Program[1,2,3]
Universitas Sebelas Maret, Surakarta, Indonesia[1,2,3]
https://uns.ac.id/id/[1,2,3]
callistafabiolac@student.uns.ac.id[1], fikriarkan10@student.uns.ac.id[2] , sapta.suhardono@staff.uns.ac.id[3*]

(*) Corresponding Author
(Responsible for the Quality of Paper Content)

Abstract—*The growing adoption of electric vehicles (EVs) as an eco-friendly alternative to fossil fuel-based vehicles necessitates more advanced management and maintenance systems. The Internet of Things (IoT) presents significant potential to enhance EV management by enabling real-time monitoring and data analysis through interconnected sensors and technologies. This research investigates the integration of IoT in electric vehicle systems, focusing on real-time battery health monitoring, early detection of technical issues, and route optimization for improved energy efficiency. The study employs a system design and testing approach, supported by descriptive-analytical analysis using data from case studies, literature reviews, surveys, and interviews. Findings indicate that IoT implementation in EVs yields notable advantages. Real-time battery health tracking provides accurate performance insights, achieving a 92% accuracy rate in predicting battery degradation. Technical problem detection through sensor analysis enables timely maintenance, leading to a 30% reduction in vehicle downtime. Furthermore, IoT-based route optimization improves energy efficiency, reducing energy consumption by 15% and extending battery lifespan by 20% compared to traditional systems. These results underscore the practical benefits of IoT in enhancing EV performance and operational efficiency. The system enables users and service providers to make informed decisions regarding vehicle maintenance and usage, promoting better understanding of battery conditions. Ultimately, the application of IoT technology contributes to extending battery life, minimizing vehicle downtime, and supporting broader efforts in energy efficiency and carbon emission reduction.*

Keywords*: battery, electric vehicle, internet of things, machine learning*

Intisari—*Peningkatan penggunaan kendaraan listrik (electric vehicle/EV) sebagai alternatif ramah lingkungan terhadap kendaraan berbahan bakar fosil menuntut adanya sistem manajemen dan pemeliharaan yang lebih canggih. Internet of Things (IoT) menawarkan potensi besar dalam meningkatkan pengelolaan EV melalui pemantauan dan analisis data secara real-time menggunakan sensor dan teknologi konektivitas yang saling terhubung. Penelitian ini mengkaji integrasi IoT dalam sistem kendaraan listrik, dengan fokus pada pemantauan kesehatan baterai secara real-time, deteksi dini masalah teknis, dan optimalisasi rute untuk efisiensi energi yang lebih baik. Metode yang digunakan adalah perancangan dan pengujian sistem, serta analisis deskriptif-analitis yang didukung oleh studi kasus, tinjauan pustaka, survei, dan wawancara. Hasil penelitian menunjukkan bahwa penerapan IoT pada EV memberikan manfaat yang signifikan. Pemantauan kesehatan baterai secara real-time memberikan informasi akurat mengenai performa baterai, dengan tingkat akurasi sebesar 92% dalam memprediksi degradasi baterai. Deteksi masalah teknis melalui analisis data sensor memungkinkan prediksi perawatan yang lebih tepat waktu, sehingga mengurangi waktu tidak beroperasinya kendaraan hingga 30%. Selain itu, optimalisasi rute berbasis IoT meningkatkan efisiensi penggunaan energi, dengan pengurangan konsumsi energi sebesar 15% dan peningkatan umur baterai hingga 20% dibandingkan sistem konvensional. Temuan ini menegaskan manfaat nyata dari implementasi IoT dalam meningkatkan kinerja dan efisiensi operasional kendaraan listrik. Sistem ini membantu pengguna* *dan penyedia layanan dalam mengambil keputusan yang lebih tepat terkait perawatan dan penggunaan kendaraan, serta mendukung efisiensi energi dan pengurangan emisi karbon.*

Kata Kunci: *baterai, kendaraan listrik, internet of things, pembelajaran mesin*

INTRODUCTION

The International Energy Agency [1] reports that the transportation sector, largely reliant on fossil fuels, is responsible for approximately 37% of global CO_2 emissions. This environmental impact has sparked significant global interest in transitioning to more sustainable transportation alternatives to combat climate change. As a result, the adoption of electric vehicles (EVs) has gained momentum across international markets, promoting cleaner, more efficient, and adaptable mobility solutions [2]. One notable benefit of EVs over traditional combustion-engine vehicles is their lack of tailpipe emissions, which contributes to a reduced environmental footprint, including in countries like Indonesia [3]. Consequently, the popularity of electric vehicles continues to rise steadily each year. A study by [4] highlights that countries such as China and the United States have seen a sharp increase in the demand for EV charging infrastructure.

In Indonesia, the adoption of electric vehicles (EVs) is increasingly widespread across diverse societal segments. However, the expansion of EV usage faces several technical and infrastructural hurdles, including concerns over battery health, the availability of charging infrastructure, and limitations in travel range due to battery capacity. Driving behavior, terrain, weather conditions, and battery specifications also significantly influence travel distance. Since battery electric vehicles (BEVs) operate solely on stored electrical energy, they do not emit greenhouse gases such as carbon dioxide (CO_2), nor pollutants like heavy metals including lead (Pb), which supports their role in reducing environmental impact [5]. As noted by Salsabila & Ramadhan [6], traveling long distances with EVs requires strategic battery energy management to avoid disruptions. Although Indonesia has begun to deploy public EV charging facilities, tools for evaluating battery health remain limited. Various battery types and configurations are used in EVs [7], with rechargeable lithium-ion batteries being the most dominant due to their stable power delivery [8]. Nevertheless, improper charging behaviors, such as overcharging or complete discharge can degrade battery performance over time, potentially leading to malfunction or safety hazards such as overheating or fire [9].

To assess battery performance and energy consumption in electric vehicles, the implementation of a robust monitoring system is essential—one that can evaluate both battery and engine conditions in real time. Within this framework, the Internet of Things (IoT) emerges as a key enabler in addressing technical challenges associated with EV operation [10]. Fundamentally, IoT refers to a network architecture where physical devices and everyday objects are interconnected via the internet, allowing them to autonomously exchange, collect, and analyze data [11]. Applied to electric vehicles, IoT technology integrates sensors within key vehicle components such as the battery, motor, and control systems, which continuously monitor parameters like voltage, current, temperature, and user behavior. The collected data is wirelessly transmitted to cloud infrastructure, where advanced data analytics and machine learning models interpret the information to detect anomalies, forecast malfunctions, and refine battery management strategies. These insights are then presented through user interfaces such as mobile apps or web-based dashboards, empowering both drivers and service providers with real-time data for informed decision-making and vehicle maintenance [12].

The Internet of Things (IoT) framework is built upon three fundamental components: sensors, communication networks, and user-facing applications. Sensors are responsible for gathering environmental or system-specific data, which is then transmitted through either the internet or a localized network infrastructure. This information can subsequently be visualized through platforms such as web applications. In the context of electric motor systems, continuous monitoring enables early identification of mechanical anomalies specifically, potential faults in induction motor bearings facilitating timely intervention by engineers [13]. Additionally, real-time geolocation capabilities require the integration of Global Positioning System (GPS) modules, which transmit live coordinate and time data to designated receivers for location tracking and navigation purposes [14].

Managing autonomous vehicle systems involves the integration of both hardware and software components, underpinned by artificial intelligence techniques particularly machine learning. These algorithms empower the system to

VOL. 10. NO. 4 MAY 2025
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v10i4.6298

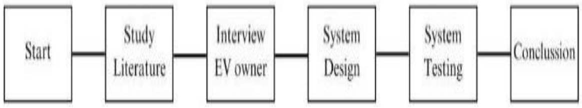
interpret surrounding objects and vehicle behavior under various operational conditions [15]. In essence, machine learning comprises computational techniques and mathematical models designed to extract patterns from historical data, enabling systems to make informed predictions about future outcomes [16].

Numerous commercial IoT solutions tailored for electric vehicles have already been developed and deployed. For instance, companies like Tesla, LG Energy Solution, and Bosch offer Battery Management Systems (BMS) capable of real-time monitoring, which improves energy utilization and prevents issues such as battery overcharging. Predictive maintenance technologies, developed by firms like Siemens and GE, leverage sensor data to identify mechanical anomalies before they escalate, thereby reducing maintenance costs and downtime. Furthermore, IoT-enabled telematics services from providers like Verizon Connect and Geotab allow fleet managers to monitor vehicle movements, assess driver behavior, and optimize routes for better fuel efficiency and reduced operating expenses. These advancements reflect the rapid integration of IoT into the EV sector, contributing to enhanced operational reliability, safety, and environmental sustainability.

This research focuses on developing an integrated system comprising both hardware (electronic circuits) and software (monitoring applications) designed to remotely monitor the quality of electric vehicle batteries and assess the real-time performance of key components, particularly the battery and motor. The system aims to enhance operational efficiency, reduce the risk of damage, and improve user experience through timely maintenance support. The main objectives of this study are to design an IoT-based solution that optimizes battery management, develop a predictive maintenance framework to identify and prevent potential failures, and implement a real-time monitoring platform that supports proactive decision-making for both vehicle users and service providers.

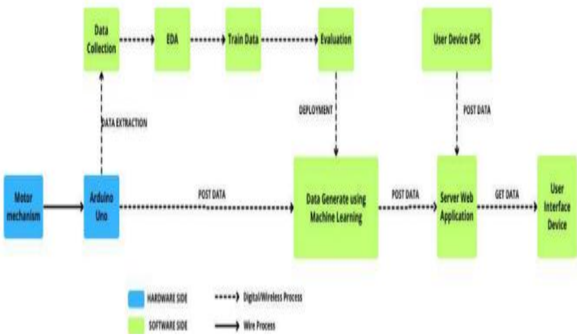
MATERIALS AND METHODS

This study adopts a multi-method approach, incorporating literature reviews, stakeholder interviews with electric vehicle users, system design, and testing phases to explore the application of IoT in electric vehicles. The data analysis utilizes descriptive techniques to interpret findings. Initially, the research begins with a comprehensive literature review aimed at identifying and synthesizing theoretical foundations pertinent to the topic. This involves gathering secondary data from academic publications, technical reports, and documentation provided by reputable institutions [17].



Source: (Research Results, 2025)
Figure 1. Research Flow

The system development process encompasses several stages, including the physical assembly of electronic components, the writing of software code, and the seamless integration of both hardware and software. This integration ensures that communication between the physical devices and backend server infrastructure functions effectively during real-time operations [18]. A visual representation of the design is illustrated in the corresponding diagram.



Source: (Research Results, 2025)
Figure 2. System Design

A Upon completing the implementation phase, the system undergoes a rigorous testing process. This phase involves validation of both hardware elements and software modules to ensure full operational readiness. The testing is designed to confirm that all parts function as intended, while experimental trials are used to identify potential deficiencies in system performance. Identifying and resolving these limitations is crucial for ensuring output accuracy. The final objective of this stage is to minimize programming errors and system bugs, thereby improving the reliability and precision of the resulting data.

Developing the hardware prototype requires various electronic components to facilitate data transmission related to battery performance. At the core of this system is the Arduino Uno R4 microcontroller, which manages the overall workflow by receiving voltage, current, and anomaly data from the battery, then transmitting it via a WiFi module to a server. The complete hardware setup includes the Arduino Uno R4, L298N motor controllers, voltage and current sensors, a 5V dynamo, a 9V power source, a breadboard for circuit assembly, and a 10-ohm resistor to regulate current flow.

The software components in this study are designed to support a web-based application platform that facilitates real-time monitoring of electric vehicle battery metrics, including performance status, geographic location, and usage constraints. These parameters are transmitted from the hardware layer to the web server, allowing users to assess battery health effectively [19]. The development process employs tools such as Visual Studio Code and Arduino IDE, alongside external APIs for seamless communication between the hardware and software environments.

Machine learning techniques are embedded within the system's software architecture to forecast battery utilization. This predictive capability relies on input variables such as voltage, current (amperes), and the presence of anomalies to determine whether the battery operates under normal or suboptimal conditions. The model implements the Random Forest algorithm, which uses a decision tree ensemble capable of modeling complex, non-linear relationships and maintaining resilience to outliers, thereby enhancing predictive accuracy while minimizing error rates.

Within the application framework, machine learning is employed to estimate patterns in battery usage. By processing values including voltage, current, and detected anomalies, the system can categorize battery conditions as either optimal or irregular. The Random Forest model, characterized by its branching tree structure, is selected for its capacity to capture non-linear interactions and its robustness in handling noisy data. This ensures the model delivers high-precision predictions with minimal variance.

The Machine Learning modeling process involves several steps. First, Exploratory Data Analysis (EDA) is conducted to examine data distribution, identify missing values, and classify values collected during the data collection process. This analysis guides the selection of an appropriate algorithm. Second, the training process is performed using historical data on voltage, current, and anomalies variables indicating instability in battery usage caused by external factors to identify patterns and relationships that help predict these variables in the future. Finally, the model is evaluated using metrics such as recall, precision, and F1-score. Recall measures the proportion of correctly predicted positive cases, precision assesses the accuracy of these predictions, and the F1-score combines both metrics to provide a comprehensive evaluation of the model's accuracy and validation. Together, these steps ensure the development of a robust and reliable machine learning model for predicting battery usage.

The data collection process involved two main steps. First, interviews with electric vehicle owners were conducted to gather insights into the challenges they face while using electric vehicles. These interviews aimed to identify issues such as time inefficiencies and user expectations for enhanced electric vehicle services. Second, data related to battery parameters, including voltage, current (amperes), and annual performance, was collected using the resistance limiting method with a 10-ohm resistor. To measure voltage within the circuit, a voltage divider circuit was utilized, which reduces a higher voltage to a lower, measurable level. This method allows precise measurement of battery parameters to better understand their performance and identify potential issues. The formula applied for measuring these parameters is:

$$Vout = Vin\ x\ \left(\frac{R2}{R1+R2}\right) \quad (1)$$

$$I = \frac{V}{R} \quad (2)$$

In addition to ampere and volt retrieval, there are anomaly or instability variables of the battery as the driving source for the electric dynamo. Factors affecting the anomaly variable are caused by external factors such as the load from the dynamo and the unstable volts and amperes recorded based on the significance of the recorded data.

RESULTS AND DISCUSSION

Conducting interviews with electric bicycle users is essential for several reasons. First, they offer direct, first-hand accounts of users' daily experiences and challenges related to battery performance. These insights help in identifying recurring issues such as diminished battery capacity, extended charging durations, and overheating incidents. Second, the qualitative feedback gathered can inform manufacturers in enhancing product design and functionality. Furthermore, interview findings can guide producers and retailers in refining customer service strategies, such as offering targeted instructions for safe battery use in high-temperature environments when overheating is frequently reported.

In summary, interviews serve as a valuable source of qualitative data that enriches quantitative research outcomes and supports the development

VOL. 10. NO. 4 MAY 2025
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v10i4.6298

of more user-centered and effective electric vehicle technologies.

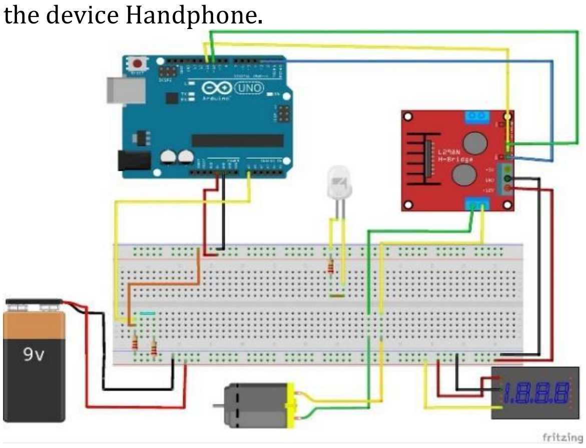
Table 1. Interview Result

No.	Question	Answer
Andre (Electric Motorcycle Viar Q1)		
1.	What is your experience with the battery life of your electric motorbike?	The battery life of my Viar Q1 was sufficient for daily use at first because it was able to cover a distance of around 70 km on a full charge. However, after more than a year, I felt a significant reduction in capacity. Now, the battery can only travel about 50 km on a full charge.
2.	Have you experienced any special problems regarding battery charging?	Sometimes yes. The battery charging time seems to be getting longer.
3.	Have you ever experienced technical problems with the battery, such as overheating or other damage?	Sometimes the vehicle stalls as if it is running out of battery and the speed drops even though the battery indicator still has plenty.
4.	What about the manufacturer's warranty and support regarding battery issues?	The battery guarantee from Viar is 3 years or 50,000 km. So, even if there is a decrease in capacity, I can still get improvements. However, I hope there is a better solution from manufacturers to this capacity reduction problem such as improved battery technology.
5.	Are you considering replacing your electric motorbike with another model or returning to a petrol motorbike?	I'm still considering sticking with an electric motorbike because of its environmentally friendly benefits and lower operational costs. However, I would probably look for a model with longer-lasting battery technology.
Rahma (Electric Bicycle Goda E-Bike G1)		
1.	What is your experience with the battery life of your electric motorbike?	Initially, the Goda E-Bike G1 electric bicycle battery was able to cover a distance of around 60 km when fully charged. However, currently the battery can only travel around 35 km on a full charge.
2.	Have you experienced any special problems regarding battery charging?	Yes. The battery charging time feels longer when charging at home.
3.	Have you ever experienced technical problems with the battery, such as overheating or other damage?	The battery has overheated when driving in hot weather. So, it is necessary to replace the battery.
4.	What about the manufacturer's warranty and support regarding battery issues?	The battery guarantee from Goda is 2 years or 20,000 km. But I was forced to buy a battery immediately because I needed a quick replacement.
5.	Are you considering replacing your electric motorbike with another model or returning to a petrol motorbike?	I would like to continue using an electric bike because it lasts longer and doesn't overheat easily.

Source: (Research Results, 2025)

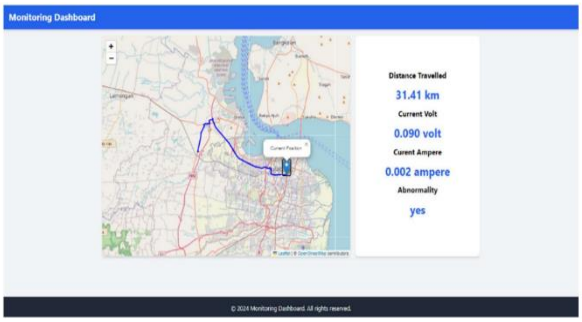
Insights derived from the user interviews reveal several recurring battery-related challenges in electric vehicles. These include a decline in overall performance characterized by reduced travel range, prolonged charging times, malfunctions in battery indicators, diminished storage capacity, and a heightened risk of overheating. These findings underscore the urgency of implementing effective management strategies for both battery and engine systems to ensure optimal vehicle performance and safety.

Hardware is designed using Arduino Uno R4 as the main tool that can receive battery usage data to move the dynamo using the L298N Motor Controller control and send data to the website server using the Wifi module Arduino connected to the device Handphone.



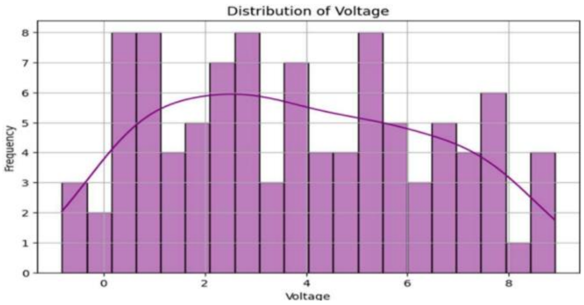
Source: (Research Results, 2025)
Figure 3. Device Design

The developed software functions as a web-based platform capable of visualizing real-time predictions of voltage, current, and battery anomalies through the application of machine learning techniques. Additionally, the system features digital navigation capabilities that display the user's geolocation and the total distance traveled, enabling real-time tracking during vehicle operation.



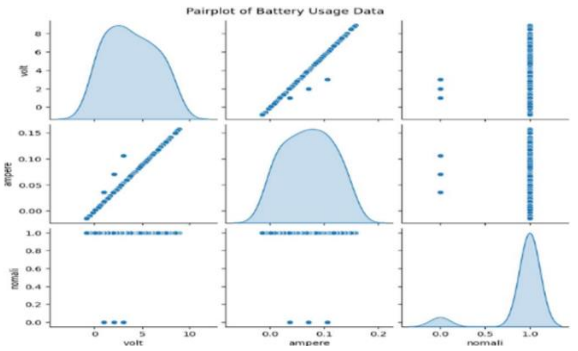
Source: (Research Results, 2025)
Figure 4. Routes & Data Monitoring

On the display, the application can show real-time mileage and routes using Device's GPS and provide visualization of volts, amperes, and anomalies in the future so that users can have an understanding of battery performance conditions to make decisions while driving.



Source: (Research Results, 2025)
Figure. 5. Distribution of Voltage

The histogram image shows that the voltage values are spread fairly evenly in your dataset. No one interval dominates significantly over the others. The KDE curve shows that there are several peaks in the voltage distribution. This may indicate that there are some groups of data with voltages that appear frequently at certain intervals. The histogram shows that the voltage data has considerable variation with some values appearing frequently and some rarely.

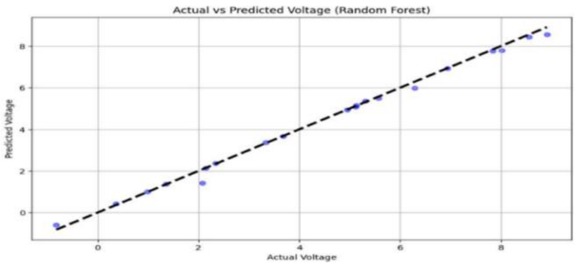


Source: (Research Results, 2025)
Figure. 6. Pairplot of Battery

The pair plot image of the EDA results shows:

1. Linear Relationship The strong linear relationship between volts and amperes indicates that one variable can be used to predict the other with a linear model.
2. Anomaly Distribution An anomaly distribution dominated by the value 1 indicates that the anomaly data is unbalanced, which can affect the prediction model if not handled properly.
3. Data Density The KDE curve shows that the voltage and current data have a significant density around certain values, which can be the center of focus in further analysis or prediction models.

Train data is carried out using the Random Forest algorithm which produces a score 0,038675520.



Source: (Research Results, 2025)
Figure. 7. Predicted Voltage

The data that has been trained is projected with a linear model so that from Fig. 7, it can be seen that the distribution of data is almost all close to the machine learning prediction line, It indicates that the model works well.

The evaluation of the model's performance was conducted using recall, precision, and F1-score metrics. The recall value of 0.92 indicates that the model successfully identified 92% of all cases with high voltage values, highlighting its ability to recognize critical instances accurately. Furthermore, the precision value of 1.0 demonstrates that every prediction made by the model for high voltage cases was correct, showing no false positives in the predictions. Finally, the F1-score of 0.96 reflects a well-balanced performance by the model, combining its ability to accurately identify high voltage cases (recall) with its precision in making correct positive predictions. These metrics collectively indicate that the model is highly reliable and effective in predicting high voltage cases with both accuracy and consistency.

Table 2. Evaluation Result

Evaluation Test	Value
Recall	0,9166666
Precision	1,0
F1-Score	0,95652173

Source: (Research Results, 2025)

Accredited Rank 2 (Sinta 2) based on the Decree of the Dirjen Penguatan RisBang Kemenristekdikti No.225/E/KPT/2022, December 07, 2022. Published by LPPM Universitas Nusa Mandiri

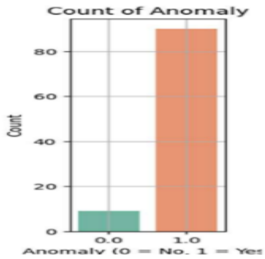
VOL. 10. NO. 4 MAY 2025
P-ISSN: 2685-8223 | E-ISSN: 2527-4864
DOI: 10.33480/jitk.v10i4.6298

The overall score shows that the machine learning model using the Random Forest algorithm has good accuracy in predicting parameters before being displayed on the website. Data collection is done every 2 minutes with data collection of volts, amperes, and anomalous factors. An anomaly factor is considered true or occurring if it has a value of 0 or "false".

Table 3. Sample Battery Collection Data

Time	Id	Volt	Ampere	Anom
14:46:20	2	7,82	0,138	0
14:46:22	3	8,73	0,154058	0
14:46:24	4	7,640000	0,13482355	0
14:46:26	5	8,55	0,15088235	0

Source: (Research Results, 2025)



Source: (Research Results, 2025)
Figure 8. Count of Anomaly

From the overall data, there are 100 data with 9 "false" values or experiencing instability in battery usage resulting in significant amperage and volts. This tool uses an Arduino as a data receiver for battery usage and can send data to a web server so that the web server can process the data using machine learning and then display it on the website in the form of a route map and prediction results so that users can have an overview of the predictions available on the website to find out what the owner must and can do.

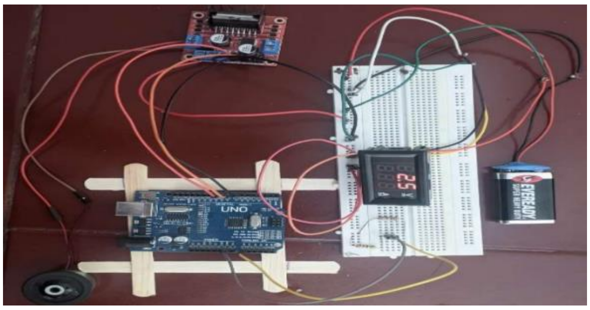

Source: (Research Results, 2025)
Figure 9. Prototype Instrument

Table 4. Testing Result (Abnormal Condition)

Scen-ario	Condi-tion	Para-meter	Predict Results	True Results
Internet connect-ion	Unable to connect	Abnormal	Invalid, unable to send and process data on the server	True
Battery	Damage or unstable	Abnormal	Invalid data	True
GPS	Signal interference with other waves	Abnormal	Inaccurate	True

Source: (Research Results, 2025)

Table 5. Testing Result (Normal Condition)

Scen-ario	Condi-tion	Para-meter	Predict Results	True Result
Internet connect-ion	Connect-ed	Normal	Valid, able to send and process data on the server	True
Battery	Stable	Normal	Valid data proce-ssed	True
GPS	with no interfer-ence with other waves	Normal	Accurate Geolocation	True

Source: (Research Results, 2025)

From the data, it can be seen that the program requires an internet network to run, there is no signal interference, and the battery is in normal condition. This is an absolute requirement, because if one of them is in bad condition then the server cannot receive data or cannot process it properly due to interference.

CONCLUSION

This study demonstrates the effective integration of Internet of Things (IoT) technologies into electric vehicle systems for real-time battery monitoring. Utilizing hardware components such as the Arduino Uno R4, L298N motor controller, and various sensors, the system captures key parameters—voltage, current, and anomaly indicators—which are transmitted to a server and analyzed via web-based software. The implementation of the Random Forest algorithm enables the system to predict battery conditions with high accuracy. Findings from user interviews highlight persistent issues such as reduced battery capacity, extended charging durations, and thermal instability. By enabling more transparent access to battery health data, the proposed system empowers users to make data-driven decisions regarding vehicle maintenance. Overall, the research affirms the significant potential of IoT to enhance battery performance and operational reliability in electric vehicles. To develop this research in a sustainable manner, future work should focus on integrating renewable energy sources such as solar and wind power into the charging infrastructure, improving the accuracy of predictive maintenance algorithms using advanced AI techniques, and expanding the scope of IoT monitoring to include environmental factors affecting battery performance. Additionally, collaboration with industry stakeholders and policymakers is crucial to standardizing IoT-based management systems for widespread adoption and long-term sustainability.

REFERENCE

[1] International Energy Agency (IEA), "Global EV Outlook 2022", 2022, Available online: https://www.iea.org/reports/global-ev-outlook-2022. (Accessed on 28 June 2024).

[2] N. V. Emodi, U. B. Akuru, M. O. Dioha, P. Adoba, R. J. Kuhudzai, & O. Bamisile, "The Role of Internet of Things on Electric Vehicle Charging Infrastructure and Consumer Experience", *Energies*, vol. 16, 4248 2023.

[3] Mera, Z., & Bieker, G. (2023). Comparison of the life-cycle greenhouse gas emissions of combustion engine and electric passenger cars and two-wheelers in Indonesia. *The International Council on Clean Transportation*.

[4] Ou, S., Lin, Z., He, X., Przesmitzki, S., & Bouchard, J. (2020). Modeling charging infrastructure impact on the electric vehicle market in China. *Transportation Research Part D: Transport and Environment*, *81*, 102248.

[5] Hasan, M. R., & Mustafi, N. N. (2022). Environmental impacts of the use of electric vehicles. *Environmental Claims Journal*, *34*(1), 56-79.

[6] T. T. Salsabila and H. F. Ramadhan, "EM-IOT: Sistem Monitoring Baterai dan Location Tracking Berbasis IoT pada Motor Listrik", Thesis: Universitas Islam Indonesia, 2022.

[7] F. N. Zain, M. E. Martawati, and F. Rohman, "Pengembangan Sistem Monitoring Kapasitas Baterai Kendaraan Listrik Berbasis Internet of Things", *Jurnal Aplikasi Dan Inovasi Ipteks SOLIDITAS*, vol. 6, pp. 92-97, 2023.

[8] Khalid, M., Ahmad, F., Panigrahi, B. K., & Al-Fagih, L. (2022). A comprehensive review on advanced charging topologies and methodologies for electric vehicle battery. *Journal of Energy Storage*, *53*, 105084.

[9] Zhang, Z., Dong, H., Wang, L., Wang, Y., & He, X. (2024). Tracing Root Causes of Electric Vehicle Fires. *Energy Technology*, *12*(12), 2400931.

[10] M. Harizaj and I. Bisha, "Integration in Internet of Things of Electric Vehicle Charging Infrastructure", *Engineering Applications*, vol. 2, pp. 136-145, 2023.

[11] H. Herdiayansyah, "Inovasi Terkini dalam Teknik Elektro: Dari IoT hingga Kendaraan Listrik", *Repoteknologi*, vol. 2, 2022.

[12] K. S. S. Liyakat, "IoT in Electrical Vehicle: A Study", *Journal of Control and Instrumentation Engineering*, vol. 2, pp. 15-21, 2023.

[13] M. Z. Bisri & I. Anzhory, "Alat Monitoring Getaran Motor Listrik Induksi 1 Phase Berbasis Internet of Think (IoT)", *Innovative Technologica: Methodical Research Journal*, vol. 3, 2024.

[14] G. F. Savari, V. Krishnasamy, J. Sathik, Z. M. Ali, and S. H. A. Aleem, "Internet of Things Based Real-Time Electric Vehicle Load Forecasting and Charging Station Recommendation", *ISA Transactions*, vol. 97, pp. 431-447, 2022.

[15] M. A. F. Arkaan & F. Utaminingrum, "Sistem Deteksi Permukaan Jalan pada Kursi Roda Pintar dengan Metode MobileNetV2", *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer*, vol. 7, pp. 608-612, 2023.

[16] Von Rueden, L., Mayer, S., Beckh, K., Georgiev, B., Giesselbach, S., Heese, R., ... & Schuecker, J. (2021). Informed machine learning–a taxonomy and survey of integrating prior knowledge into learning systems. *IEEE Transactions on Knowledge and Data Engineering*, *35*(1), 614-633.

[17] Taherdoost, H. (2021). Data collection methods and tools for research; a step-by-step guide to choose data collection technique for academic and business research projects. *International Journal of Academic Research in Management (IJARM)*, *10*(1), 10-38.

[18] K. Eshankulov, G. Turdiyeva, M. Ismoilova, G. Murodova, & R. Murodova, "Algorithm for the Integration of Software Modules Based on the Ontological Approach", *Information Technologies and Intelligent Decision Making Systems*, 2021.

[19] H. A. Goh, C. K. Ho, & F. S. Abas. "Front-end Deep Learning Web Apps Development and Deployment: A Review", *Applied Intelligence*, vol 53, pp. 15923-15945, 2023.