International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Conference Proceedings: Volume: 05 ACME – 2026 DOI:10.55041/ISJEM.ACME030
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

# Interpretable Data Driven Digital Twin Models for Estimating Electric Vehicle Battery Condition

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**Abstract -** As the automotive industry rapidly advances towards electric vehicles (EVs), accurately predicting battery states is crucial for optimizing performance, safety, and longevity. This project presents a novel approach using Explainable Data-Driven Digital Twins to predict battery states in electric vehicles. The methodology integrates various advanced machine learning algorithms, including Deep Neural Networks (DNN), Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNN), Support Vector Regression (SVR), Support Vector Machines (SVM), Feedforward Neural Networks (FNN), Radial Basis Function networks (RBF), Random Forests (RF), and Extreme Gradient Boosting (XG Boost).The primary objective of this study is to enhance the predictability of battery states by leveraging these diverse algorithms to build a comprehensive digital twin model. The model aims to provide accurate predictions of key battery parameters such as state of charge (SOC) and state of health (SOH) under various operational conditions. By utilizing explainable AI techniques, the project also focuses on interpreting and understanding the underlying factors influencing battery performance.

**Keywords:** Electric Vehicles, Battery State Prediction, Digital Twins, Machine Learning, Deep Neural Networks, LSTM, CNN, Support Vector Regression, Random Forests, Extreme Gradient Boosting.

## 1. INTRODUCTION

As the automotive industry shifts towards electric vehicles (EVs), the efficiency and reliability of battery systems have become paramount. Batteries are the core component of EVs, and their performance directly affects vehicle range, safety, and lifespan. Accurate prediction of battery states, such as state of charge (SOC) and state of health (SOH), is crucial for optimizing these parameters. However, traditional methods often fall short in handling the complex, nonlinear behavior of batteries under varying operational conditions. With the advent of advanced machine learning techniques, there is an opportunity to create more precise and explainable models that not only predict battery states but also provide insights into the factors affecting battery performance. This project is motivated by the need to develop such models, contributing to more efficient and intelligent battery management systems that will support the widespread adoption of EVs.

## 2. SYSTEM ANALYSIS

- Current systems for battery state prediction in electric vehicles rely on conventional models and empirical data.
- They often use simple linear regression or rule-based methods to estimate state of charge (SOC) and state of health (SOH).
- These approaches provide basic functionality but have limited accuracy and adaptability.
- Many existing systems lack interpretability, making it difficult to understand factors affecting battery performance.

**Existing System:**

**Limitations of Existing Systems:**

- Traditional models may not capture the complex behavior of batteries, which can lead to less accurate predictions of state of charge (SOC) and state of health (SOH).
- Many existing systems rely on fixed assumptions and may not adapt well to changing operating conditions or new battery technologies.
- Some models lack transparency, making it difficult for users to understand how predictions are generated.
- Existing systems often use oversimplified assumptions about battery behavior, which may ignore important factors affecting performance.

## 3. PROPOSED SYSTEM

The proposed system aims to enhance battery state prediction in electric vehicles through the development of Explainable Data-Driven Digital Twins. This system leverages a suite of advanced machine learning algorithms, including Deep Neural Networks (DNN), Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNN), Support Vector Regression (SVR), Support Vector Machines (SVM), Feedforward Neural Networks (FNN), Radial Basis Function networks (RBF), Random Forests (RF), and Extreme Gradient Boosting (XG Boost). By integrating these diverse algorithms, the system is designed to deliver highly accurate and reliable predictions of critical battery parameters such as state of charge (SOC) and state of health (SOH). Additionally, the system incorporates explainability features, providing transparency into the factors influencing battery performance and enhancing user trust.

**Advantages of Proposed Systems:**

- The system uses advanced machine learning algorithms to improve the accuracy of predicting battery parameters such as state of charge (SOC) and state of health (SOH).
- It can adapt to different operating conditions and changes in battery technology, providing more reliable predictions.
- The model improves transparency, helping users understand the factors that influence battery performance.
- It combines multiple data sources such as environmental conditions and battery usage patterns for better analysis.

**System Architecture:**

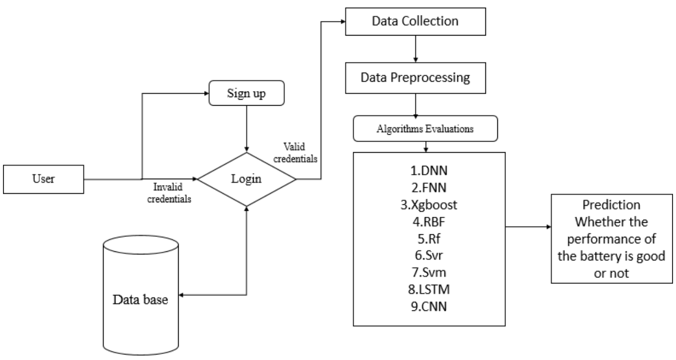


**Fig -1**: Architecture

## 4. CONCLUSION

This research introduces a pioneering approach using Explainable Data-Driven Digital Twins for predicting battery states in electric vehicles (EVs), leveraging a diverse array of advanced machine learning algorithms. By integrating models such as Deep Neural Networks (DNN), Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNN), Support Vector Regression (SVR), Support Vector Machines (SVM), Feedforward Neural Networks (FNN), Radial Basis Function networks (RBF), Random Forests (RF), and Extreme Gradient Boosting (XG Boost), we have developed a comprehensive digital twin model that enhances the accuracy and reliability of battery state predictions .The primary objectives of this study improving the predictability of key battery parameters like state of charge (SOC) and state of health (SOH) have been successfully met.

## FUTURE SCOPE

Future improvements can include collecting more data from sensors, vehicle conditions, and environmental factors to improve prediction accuracy. Advanced machine learning techniques such as hybrid models and transfer learning can further enhance the system's performance. Improving explainable AI methods can help users better understand how predictions are made. Real-time learning can allow the model to update as new data becomes available. Using edge computing can help perform faster predictions directly inside the vehicle.

## REFERENCES

1. Jia, L., & Zhang, Y. (2018). Study on machine learning methods
2. Wang, X., & Zhang, J. (2020). Research on predicting battery state of charge and health.
3. Lee, J., & Kwon, Y. (2019). Review of data-driven digital twins in smart manufacturing.4. Palau (2020) – Deep learning DNS detection.
4. Liu, H., & Zhao, Y. (2021). Overview of explainable artificial intelligence techniques.
5. Wang, S., & Wang, Y. (2021). Study on deep learning applications in battery management.
6. Yuan, Y., & Xu, J. (2020). Use of LSTM neural networks for battery state prediction.7. Saeli (2020) – Behavioral DNS attack detection.

## BIOGRAPHY

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ISSN: 2583-6129
DOI:10.55041/ISJEM.ACME030

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