RAJALAKSHMI ENGINEERING COLLEGE
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Department of Computer Science and Engineering

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Smart Battery Health Monitoring and Maintenance System

SUBRAMANIAN N - 230701348
THIRUMURUGAN - 230701364

ABSTRACT

As the world shifts toward battery-powered technologies — from electric vehicles to portable gadgets — monitoring battery health in a smart, efficient way has become more important than ever.

- ◇ Our project introduces an IoT-based Smart Battery Health Monitoring and Maintenance System, designed with a user-first approach using design thinking.
- ◇ We built a system using an Arduino Uno connected to voltage (DG-301), current (ACS712), and temperature (DHT11) sensors to collect real-time battery data.
- ◇ This data is sent to an intuitive Electron.js desktop app, where users can easily track and visualize their battery's performance.
- ◇ To take it a step further, we integrated an LSTM machine learning model that predicts the battery's Remaining Useful Life (RUL) and State of Health (SoH).
- ◇ With real-time insights and future predictions, the system helps users maintain their batteries better, prevent failures early, and promote more sustainable energy practices.

Introduction

Batteries are at the heart of modern technology — powering everything from electric vehicles to smartphones to renewable energy grids.However, over time, batteries naturally degrade due to usage, environmental factors, and aging, leading to unexpected failures if not monitored properly.

- To address this, we developed a Smart Battery Health Monitoring and Maintenance System, combining IoT, real-time data collection, and machine learning.
- Using an Arduino Uno and sensors (DG-301 voltage sensor, ACS712 current sensor, DHT11 temperature sensor), we gather critical battery health data.
- This information is displayed live through a desktop application built with Electron.js, offering users clear, real-time insights.
- To predict the future performance of the battery, we use an Machine learning to estimate the Remaining Useful Life (RUL) and State of Health (SoH).
- Our goal is simple: empower users to monitor, maintain, and extend the life of their batteries proactively.

Problem Statement

Battery degradation is a significant issue in various applications, such as electric vehicles, renewable energy storage, and portable electronics. Existing battery monitoring systems are often limited to basic parameters like voltage and current, neglecting crucial factors like temperature and battery health. Without real-time monitoring and predictive maintenance, batteries may fail unexpectedly, leading to costly replacements and inefficiencies. Current solutions lack intelligence and fail to provide accurate insights into battery life. This research aims to address these challenges by integrating IoT and machine learning to offer a predictive battery monitoring system, enabling users to manage battery performance proactively.

Proposed Work

- The system continuously monitors key battery parameters like voltage, current, and temperature using sensors connected to an Arduino Uno. This enables real-time tracking of the battery's health and performance.
- Data collected from the sensors is transmitted to an Electron.js desktop application, which visualizes the information and allows users to monitor the battery's behavior in real-time. The application also logs historical data for further review.
- The system uses the Arduino Uno to process and transmit the data, ensuring smooth communication between the sensors and the software application. This seamless integration ensures reliable data collection and transmission.
- Finally, the integration of an LSTM machine learning model allows the system to predict the Remaining Useful Life (RUL) and State of Health (SoH) of the battery. This predictive capability supports early failure detection and proactive maintenance to optimize battery performance.

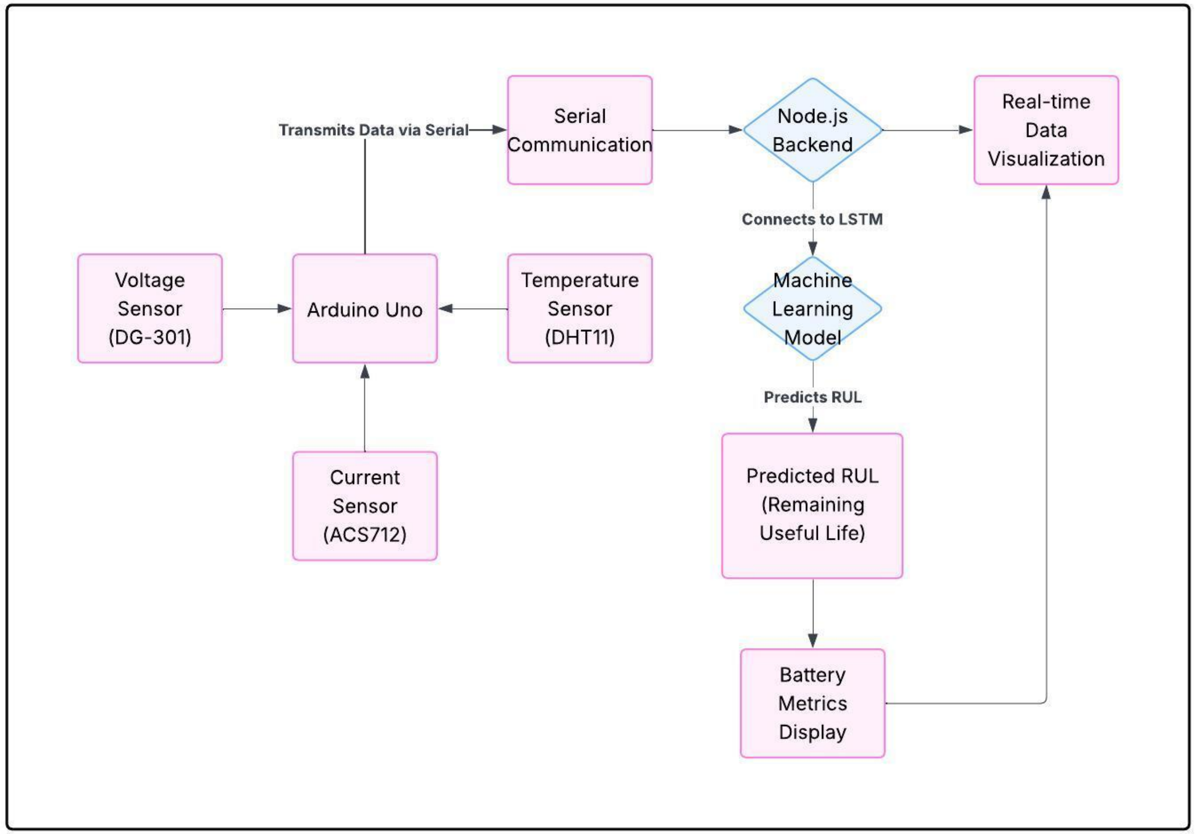
Implementation

- The implementation of the Smart Battery Health Monitoring and Maintenance System follows a structured approach, combining hardware, software, and machine learning to create a seamless and efficient solution for real-time battery monitoring and predictive analysis.
- First, the hardware setup involves integrating key components such as the Arduino Uno, DG-301 voltage sensor, ACS712 current sensor, and DHT11 temperature sensor. These sensors continuously monitor critical battery parameters such as voltage, current, and temperature, which are essential for assessing the battery's health and performance. The Arduino Uno processes the sensor data and transmits it via a serial port to the desktop application.
- On the software side, the desktop application is built using Electron.js and Node.js. The application provides a user-friendly interface for real-time data visualization, displaying dynamic charts and graphs that update in real-time. Users can track battery health indicators like State of Charge (SoC), State of Health (SoH), and Remaining Useful Life (RUL). The application also stores historical data and allows users to interact with the system to get insights into battery performance trends.

Implementation

- For the predictive analysis, a Long Short-Term Memory (LSTM) neural network is employed to analyze the time-series data collected from the sensors. The model is trained using historical battery data and real-time sensor measurements. It predicts the RUL and SoH of the battery, providing early warning signs of potential failure and assisting in optimizing the battery’s lifespan through proactive maintenance.
- The complete system architecture ensures that the hardware, software, and machine learning components work together seamlessly, providing accurate and actionable insights into battery health.

Architecture



Hardware requirements

- Arduino Uno: Acts as the central microcontroller, collecting and transmitting data from the sensors.
- DG-301 Voltage Sensor: Measures the battery's voltage, a critical indicator of battery health.
- ACS712 Current Sensor: Monitors the current flowing through the battery to assess power consumption and detect abnormal current spikes.
- DHT11 Temperature Sensor: Measures the battery temperature to monitor its thermal state and prevent degradation due to overheating.
- Connecting Wires: To connect the sensors and Arduino Uno for data transmission.
- Breadboard: For prototyping and connecting components.

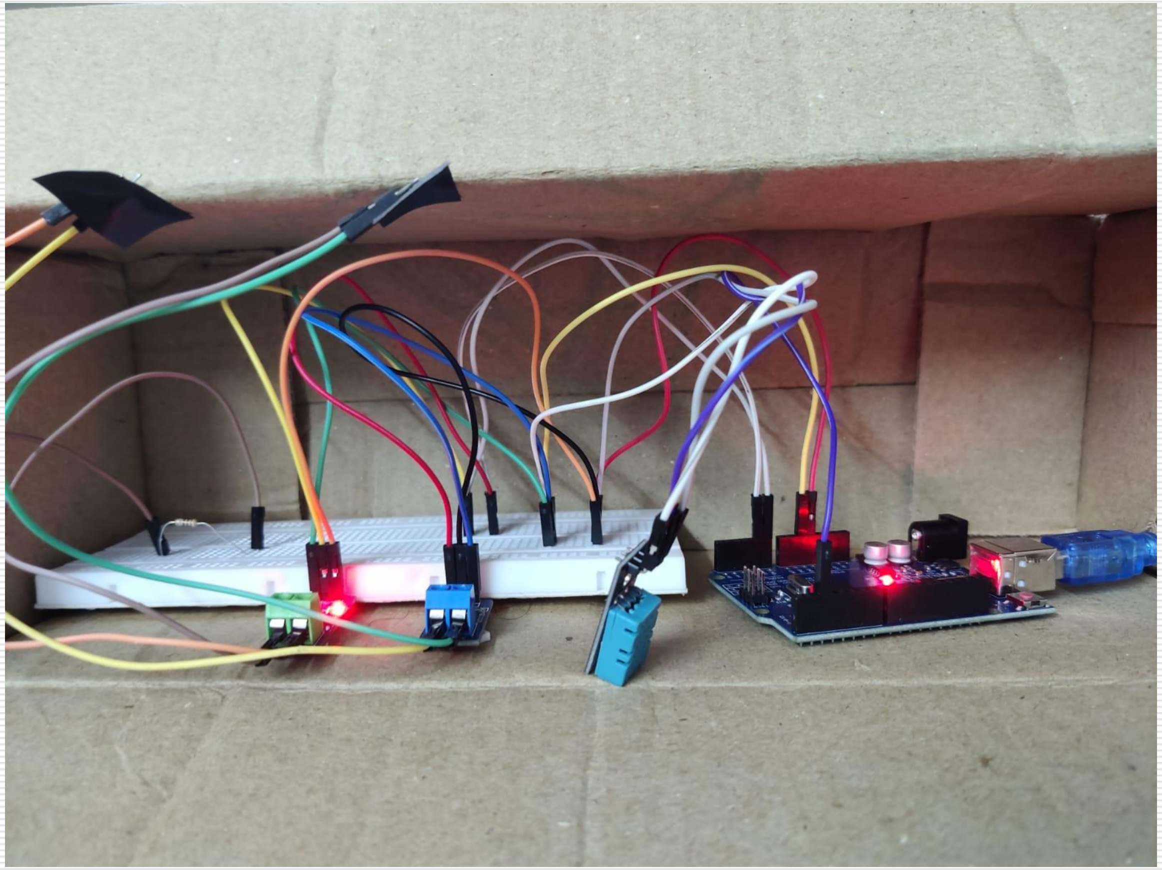
Software requirements

- Electron.js: For developing the desktop application that provides the user interface and visualizes real-time data.
- Node.js: Backend environment for managing communication between the Arduino and the Electron.js frontend.
- Serial Communication Library: For enabling data transmission between the Arduino and the desktop application.
- TensorFlow.js: For integrating the machine learning model (LSTM) into the system, enabling real-time predictive analytics.
- Database: To store historical battery data for performance tracking.

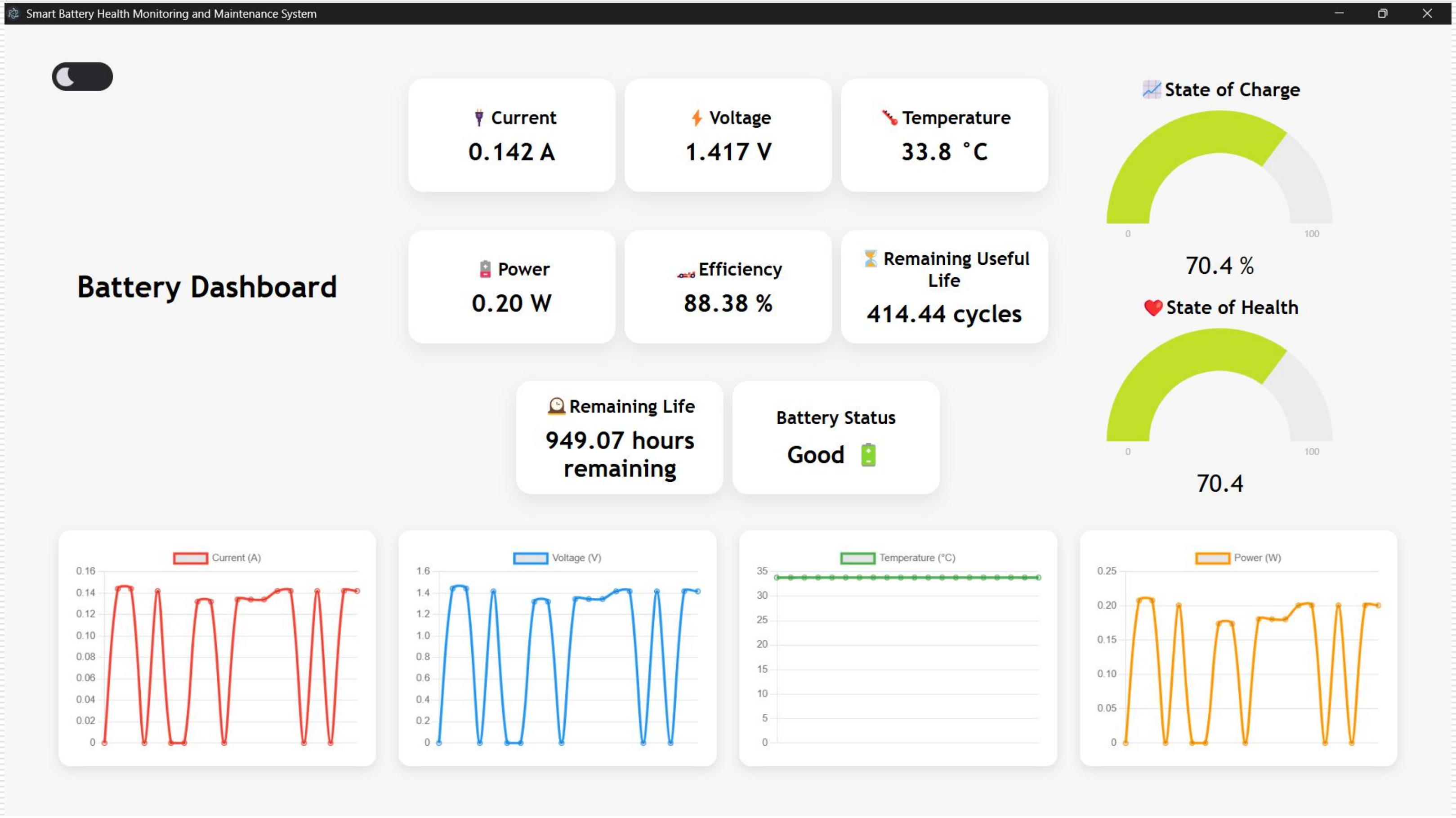
Advantages of the proposed system

- Real-time Monitoring: Continuously tracks battery parameters, providing immediate data for detecting issues and ensuring timely maintenance.
- Predictive Analytics: Utilizes an LSTM model to predict Remaining Useful Life (RUL) and State of Health (SoH), helping to prevent unexpected battery failures.
- Proactive Maintenance: Early failure detection enables planned maintenance, improving reliability and reducing downtime.
- User-Friendly Interface: The desktop application offers an intuitive platform for visualizing battery performance and managing data.

SBHMMS



User Dashboard



Conclusion

In conclusion, the Smart Battery Health Monitoring and Maintenance System offers a robust solution for monitoring and predicting battery health in real-time. By leveraging IoT, machine learning, and user-friendly design principles, the system enhances battery performance, reduces failure risks, and supports proactive maintenance. This integrated approach not only provides accurate insights into the battery's condition but also optimizes its usage and longevity, making it a valuable tool for various applications like electric vehicles, renewable energy storage, and portable electronics. The proposed system aligns with the growing need for intelligent battery management and plays a significant role in ensuring reliability and efficiency in battery-powered systems.

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Thank You