AI-POWERED EV BATEERY FIRE PREVENTION SYSTEM

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Keywords:

AI Detection, Battery Safety, Thermal Monitoring, Fire Prevention

Introduction:

Electric vehicles (EVs) are becoming more popular as a cleaner and sustainable mode of transportation. However, battery safety is still a major concern, especially with lithium-ion batteries that can overheat or catch fire due to faults like overcharging or short circuits. Incidents of EV fires have raised serious questions about safety and reliability.
Most existing battery management systems focus only on basic monitoring and may not detect problems early. This is where our project comes in. We aim to develop an AI-powered system that can monitor battery conditions in real time and identify unusual patterns before they become dangerous.
By using sensors like temperature and gas sensors, along with intelligent data analysis, the system can provide early warnings to prevent fire hazards. It also sends alerts to the user, allowing quick action to be taken.
Overall, this project focuses on improving EV safety by making battery monitoring smarter, faster, and more reliable.

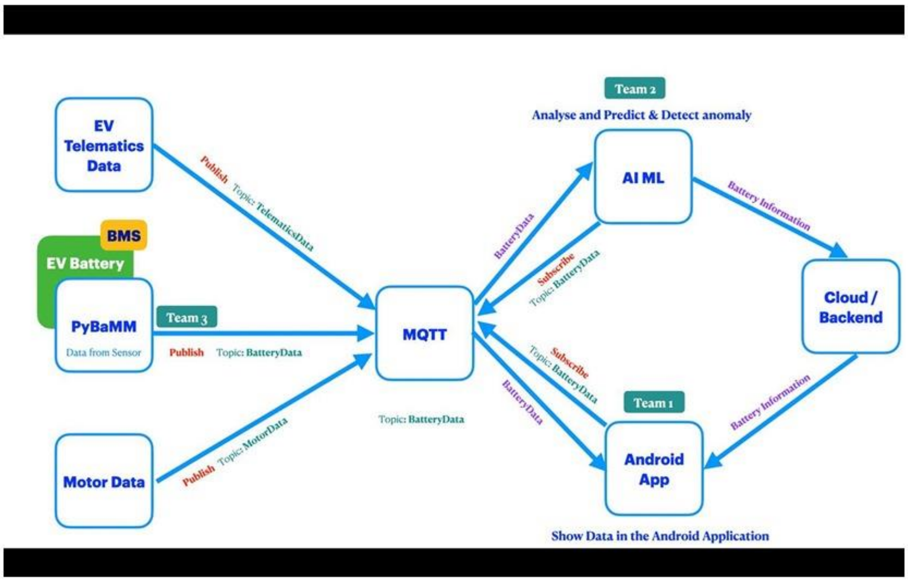

Figure 1: Architectural diagram

Objectives:

1. To develop a compact and reliable hardware platform using ESP32 and multiple sensors capable of measuring critical EV battery parameters such as temperature, voltage, current, motor load, speed, and GPS location in real time.
2. To provide an easy-to-use, student-friendly IoT solution that bridges theoretical concepts of battery safety with practical experimentation, allowing users to clearly observe EV battery behaviour under different operating conditions.
3. To design accurate and consistent data-acquisition and communication methods so that battery readings remain stable, repeatable, and reliable across various load conditions and environmental scenarios.
4. To implement an AI-based anomaly detection model that analyses live battery data and identifies early signs of thermal runaway, overheating, or abnormal current flow before they escalate into fire-risk events.

Methodology:

The methodology of this project is based on continuously monitoring the condition of an EV battery to prevent fire hazards. Various sensors such as temperature sensors, gas sensors, and voltage/current sensors are used to collect real-time data from the battery. This data is processed using a microcontroller like Arduino, which acts as the central unit of the system. It continuously reads sensor values and checks for any abnormal changes, such as a sudden increase in temperature or the presence of harmful gases, which could indicate a potential fire risk. This ensures that even small changes in battery behavior are noticed early.

The collected data is then analyzed using simple AI-based logic or programmed conditions to identify unsafe situations at an early stage. If any abnormality is detected, the system immediately sends alerts to the user through IoT modules like Wi-Fi or GSM. This allows quick action to be taken before the problem becomes serious. By combining real-time monitoring, intelligent analysis, and instant alerts, the system provides a proactive and reliable solution to improve EV battery safety.

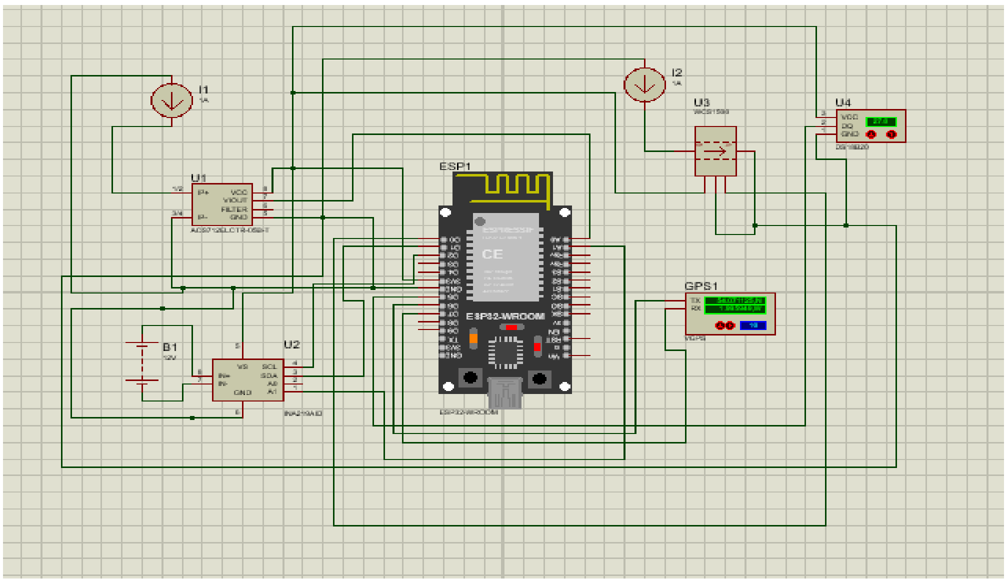

Figure 2: block diagram

Result and Conclusion:


Messages

2026-01-07 15:30:15 Topic: esp32/telemetry/battery Qos: 0

{"device_id":"ev_device_000000000000","timestamp":72539,"pack_voltage_v":465,"pack_current_a":16,"pack_power_w":7440,"soc_percent":92.9,"soh_percent":97.6,"battery_temp_c":31.2,"cell_balance":"OK","motor_rpm":21724,"motor_temp_c":291.9,"motor_current_a":22.404,"torque_nm":3.36,"charge_current_a":16,"charge_voltage_v":465,"charging_time_s":0,"speed_kmh":912.41,"gps":{"lat":12.8960463,"lon":74.9839449},"ambient_temp_c":28.9}

2026-01-07 15:30:10 Topic: esp32/telemetry/battery Qos: 0

{"device_id":"ev_device_000000000000","timestamp":67532,"pack_voltage_v":424,"pack_current_a":16,"pack_power_w":6784,"soc_percent":91.6,"soh_percent":97.7,"battery_temp_c":31.9,"cell_balance":"OK","motor_rpm":28706,"motor_temp_c":374.7,"motor_current_a":29.026,"torque_nm":4.35,"charge_current_a":16,"charge_voltage_v":424,"charging_time_s":0,"speed_kmh":1205.65,"gps":{"lat":12.8960463,"lon":74.9839449},"ambient_temp_c":26.3}

In conclusion, the results of the project demonstrate that continuous monitoring of EV battery parameters can significantly improve safety. The system was able to successfully collect real-time data from sensors such as temperature and gas sensors. During testing, it effectively identified abnormal conditions like a sudden rise in temperature or the presence of smoke-related gases. This shows that the system can detect early signs of potential battery failure.

The AI-based logic used in the system helped in analyzing patterns and distinguishing between normal and unsafe conditions. Compared to traditional systems, this approach provides faster and more reliable detection. The alert mechanism also worked efficiently by sending timely notifications to the user, allowing immediate action to be taken. This reduces the chances of serious incidents like battery fires.

From the observations, it is clear that combining sensor data with intelligent analysis creates a more effective safety solution. The system not only reacts to dangerous situations but also helps in predicting them at an early stage. This makes it more useful in real-world EV applications.

In conclusion, the project successfully achieves its goal of improving EV battery safety through smart monitoring and early warning systems. It proves that integrating AI, sensors, and IoT can create a reliable and proactive fire prevention system. This solution has the potential to enhance user confidence and contribute to safer adoption of electric vehicles in the future.

References:

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Future Scope:

The future scope of this project includes:

1. Integration with advanced AI models to improve prediction accuracy and detect complex battery faults more effectively.
2. Expansion of the system by adding more sensors, such as humidity and pressure sensors, for better and more detailed monitoring.
3. The system can be extended to support automatic safety actions, such as disconnecting the battery or activating cooling mechanisms when a risk is detected.