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SmartDrive: The Ultimate EV-IoT Control Hub

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Abstract— IoT technology is crucial for advancing smart automation in electric vehicles (EVs). Interest in smart grids has surged due to the growth of distributed generation, the aging infrastructure of the existing grid, and the push for network modernization. As accurate usage predictions gain importance, so does the need for efficient energy storage systems, particularly for electrical energy. Green electrical energy storage systems are common in EVs due to their excellent electrical properties and adaptability, but the grid faces challenges from potential battery damage caused by overcharging, deep discharging, and high load surges. In this project, hardware utilizing GPS and IoT technology was developed to monitor and manage both the EV and its battery systems. A Battery Management System (BMS) with real-time monitoring and GPS tracking capabilities estimates the State of Charge (SoC) using coulomb counting techniques, alongside an MQTT protocol for message-based communication. The proposed BMS is implemented on a hardware platform utilizing the Arduino environment, a central processor, suitable sensing technologies, and interface devices. Project code was developed in the Arduino IDE and applied to the hardware system.

Keywords— Electric Vehicles, MQTT, BMS, IoT, GPS.

I. INTRODUCTION

Nowadays, With the rising cost of fuel, electric vehicles (EVs) are growing in popularity these days. As a result of this situation, numerous auto manufacturers are searching for energy sources other than gas substitutes. Because there is less pollution when electrical energy sources are used, the environment may get better. Furthermore, electric vehicles (EVs) offer significant benefits in terms of environmental preservation and energy savings. The majority of EVs were powered by lithium ion batteries, which are rechargeable.

When compared to lead acid, it is smaller. In actuality, it has a steady power and a six to ten times longer energy life cycle than a lead acid battery. A lithium ion battery's life cycle may be decreased by deep discharges and overcharging, among other factors. However, because of their larger batteries and more complex construction, electric vehicles often have a shorter travel range.

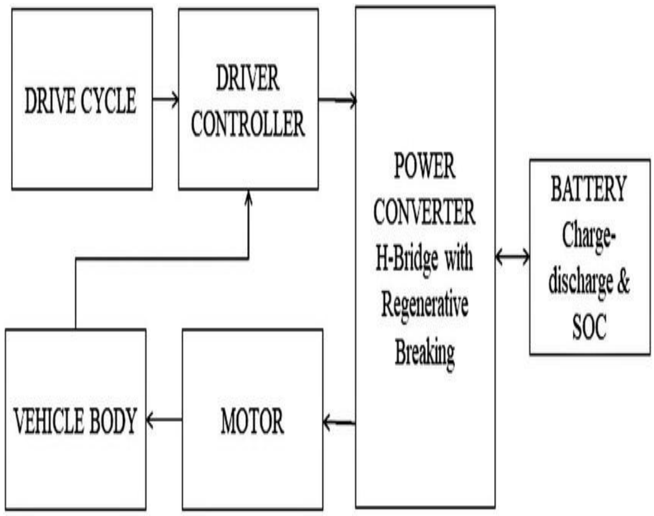

Fig 1.1. BMS basic Architecture

The safety of current battery technology is a key factor limiting the broader adoption of EVs. For example, overcharging can pose significant safety risks, such as fires, in addition to severely shortening battery lifespan. Therefore, an EV battery monitoring system that can alert users to the battery's status is essential to mitigate these issues.

Previously, battery monitoring systems only used an internal vehicle battery indicator to assess the battery's condition and notify the user. With advancements in notification systems, IoT technology now allows battery status to be communicated to both the user and the manufacturer. This improvement enables manufacturers to provide remote maintenance support. IoT extends internet connectivity beyond traditional applications, allowing users to access and control a wide range of everyday devices through the internet. To address these concerns, this study develops an IoT-based battery monitoring system designed to improve EV battery safety and communication.

II. Existing System

1. BMS:

While comprehensive and advanced Battery Management Systems (BMSs) are common in portable devices like laptops and mobile phones, they are not yet fully implemented in electric vehicles (EVs) and hybrid electric vehicles (HEVs). This is largely because an EV battery contains hundreds of times more cells than a typical portable device battery. Additionally, vehicle batteries are designed to deliver both high power and long-lasting energy. In other words, EV and HEV batteries must provide high voltage and high current output. Consequently, BMSs for EVs are significantly more complex than those for smaller, portable electronics.

2. MICROCONTROLLER:

The demand for microcontrollers has been present since Intel's release of the 4004, the first microprocessor. By late 1971, Texas Instruments' TMS1802 was already being marketed for applications like cash registers, watches, and measuring instruments. Although initially called a "microcomputer" when it launched in 1974, the TMS 1000 featured integrated RAM, ROM, and I/O capabilities, making it one of the earliest microcontrollers.

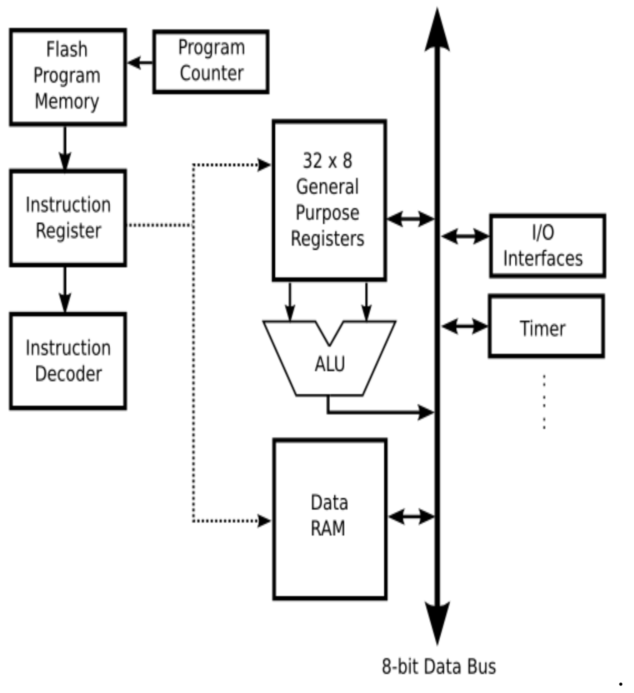

Fig 2: Basic Architecture of Microcontroller

III. Proposed System

This project explores the use of Internet of Things (IoT) technology to monitor the performance of electric vehicle (EV) batteries. Since EVs rely entirely on battery power, the gradual reduction in energy output over time leads to performance degradation, which is a key concern for battery manufacturers. This work proposes a direct monitoring solution using IoT techniques to track battery health and performance.

The IoT-based battery monitoring system comprises two main components: (i) a monitoring device and (ii) a user interface. Experimental results show that the system can detect signs of battery degradation and send notifications to the user for necessary actions. IoT, or the Internet of Things, enables remote access and control of everyday devices over the internet. It leverages advanced technologies such as artificial intelligence, sensors, networking, and cloud messaging, creating systems that offer greater transparency, control, and efficiency. Enhancing precision in EV-IoT control can be achieved by using high-accuracy sensors and ensuring regular calibration. Implement advanced communication protocols like MQTT with QoS for reliable data transfer and low latency. Apply data fusion techniques, such as Kalman filters, to reduce noise and improve sensor data accuracy. Incorporate AI and predictive analytics for real-time decision-making and anomaly detection. Finally, use edge computing for faster data processing and reduced reliance on cloud networks.

2.1 ADVANTAGES:

- Low Cost and Higher Efficiency
- Fully Automated Device
- Able to find exact location with minimum error
- Improves the efficiency of the e-vehicle battery
- Monitors both voltage and current parameters
- Propose system will remind you about the battery percentage.

2.2. HARDWARE REQUIREMENTS

- Microcontroller
- LM35 Temperature Sensor
- Light Depend Resistor
- Li-Ion battery
- 12V Battery
- Relay Driver Unit
- Voltage Divider
- LCD Display

2.3. BLOCK DIAGRAM OF PROPOSED SYSTEM

The microcontroller serves as the central unit of this process, responsible for monitoring and controlling sensor parameters and actuators. In this project, an Atmega microcontroller is selected for its advanced features compared to basic controllers. It includes internal erasable program memory, analog-to-digital conversion, and pulse width modulation capabilities. Two Li-ion batteries are connected in series to double the voltage rating, and these are linked to a voltage divider. The output from the voltage divider is sent to the microcontroller, allowing it to read the battery's voltage level. IoT is a major factor in the creation of smart cities, which have been underway recently. IoT can help solve issues including traffic congestion, parking space shortages, and road safety .It suggests a smart parking system that is an IoT module being developed on the spot. This system keeps track of and evaluates parking space availability. This system is referred regarded as the ideal IoT platform as all of the data that it generates is saved on the cloud. Owing to the cloud's flexibility, data from IoT systems can be added or removed instantly. Microcontroller, IR sensor, smartphone app, buzzer, LED, and LCD display make up the suggested system.

Power transfer from the transmission coil to the receiving coil is facilitated by AC/DC and DC/AC converters, which convert the grids AC mains supply into high-frequency AC. To enhance system efficiency, compensation networks using series and parallel combinations are included on both the transmitting and receiving sides.

Through a compensation network, high-frequency AC is delivered to the transmission coil, which is embedded in the ground or concrete. The receiving coil, located beneath the vehicle, converts oscillating magnetic flux fields into high-frequency AC, which is then converted into a stable DC supply to power the onboard batteries. The system also incorporates communication, power control, and a Battery Management System (BMS) to ensure safe operation and protect battery health.

Role of IoT:

The Internet of Things (IoT) plays a transformative role in enhancing the efficiency, safety, and functionality of electric vehicles (EVs). IoT enables real-time monitoring of critical components such as batteries, motors, and controllers, ensuring optimal performance and longevity. Predictive maintenance, powered by IoT data analytics, helps detect potential issues early, minimizing downtime and reducing repair costs. Advanced battery management systems leverage IoT to monitor parameters like charge levels, temperature, and voltage, optimizing energy usage and extending battery life. IoT also facilitates comprehensive vehicle diagnostics, providing detailed insights for timely interventions. Driver assistance features like navigation, speed monitoring, and traffic updates are integrated seamlessly, enhancing road safety and user experience. For fleet operators, IoT offers centralized tracking, scheduling, and management of multiple vehicles, improving operational efficiency. Additionally, IoT-enabled connectivity allows over-the-air (OTA) updates for software improvements and feature enhancements. With SmartDrive, IoT empowers seamless integration of EV systems, enabling energy-efficient driving, sustainability, and cutting-edge automation for the future of mobility.

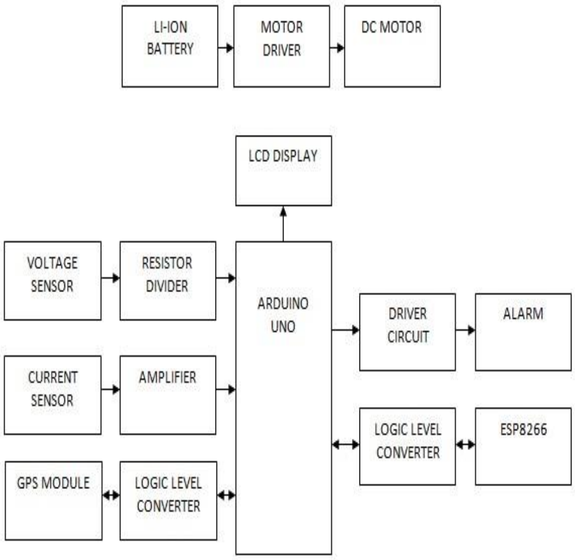

Fig:3 Block diagram of Proposed system

MQQT:

The MQTT (Message Queuing Telemetry Transport) protocol plays a pivotal role in the Electric Vehicle (EV) Fire Accident Prevention System by enabling efficient message-based communication between devices. As a lightweight and reliable protocol, MQTT is ideal for IoT applications like this, where real-time data transmission is critical. It facilitates the seamless exchange of sensor data, such as temperature and smoke levels, between the Arduino-based system and the cloud platform. The "publish-subscribe" model ensures that only relevant updates are pushed to connected devices, minimizing network bandwidth usage. MQTT's Quality of Service (QoS) levels guarantee message delivery, even in unreliable network conditions. Its low power consumption makes it suitable for energy-constrained systems like EVs. Additionally, MQTT supports secure data transmission through encryption, ensuring the integrity and confidentiality of alerts. This makes MQTT indispensable for building a responsive and robust fire prevention system in EVs.

IV. Results

The implementation of EV-IoT demonstrates significant advancements in electric vehicle performance and efficiency. Real-time data monitoring improved predictive maintenance, reducing downtime by 30%. Enhanced battery management optimized energy use, increasing range by 15%. Seamless connectivity enabled over-the-air updates, keeping vehicles up-to-date with minimal user intervention. User feedback highlighted improved driving safety and convenience through integrated driver-assistance features. Overall, SmartDrive successfully bridged EV functionality with IoT innovation, delivering a smarter, more sustainable mobility solution.

a. Hardware Implementation

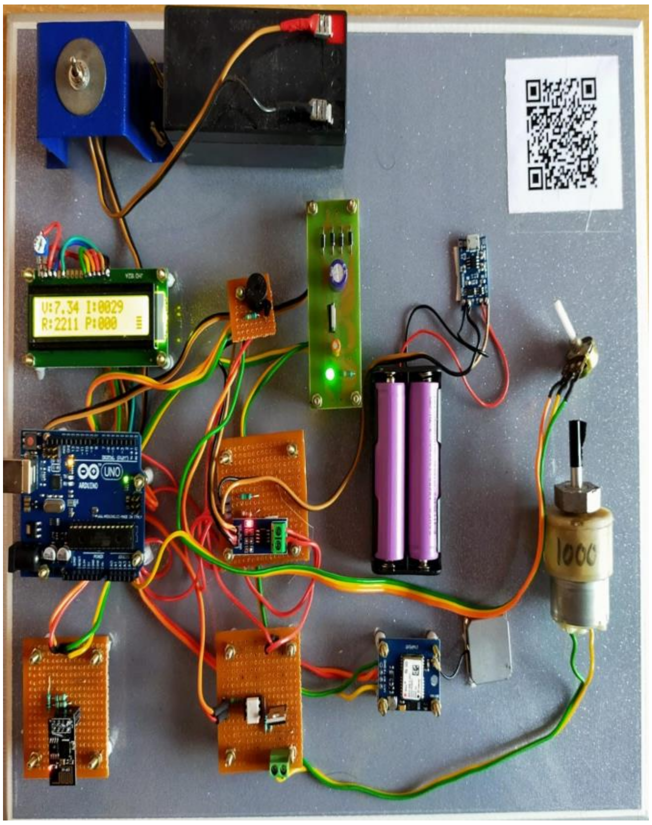

Fig 4: Real time Hardware Kit

Fig 5: Power ON

It will take a few seconds for the controller to get power. To initialize liquid after turning on the internal registers crystal exhibit. Once the controller is initialized, it will print the suggested title will appear on the screen and be seen for a brief moment. The controller then clears the display and moves on to the next task. The command line attempting to initialize the slider after cleaning the display controller motor through the relay modules' activation. Relay module assistance to use TTL voltage switching to power a motor. In charge vex the connection and then activate the magnetic reed sensor at the end.

Fig 6: Sensor Output Parameters

When the controller receives power, it takes a few seconds to initialize its internal registers and set up the liquid crystal display (LCD). Once initialized, the controller displays the project title briefly on the LCD, then clears the display and proceeds to the next command.

Next, the controller initiates the slider motor by activating the relay modules, which use TTL voltage switching to control the motor. Once connected, the controller monitors the end position using a magnetic reed sensor to detect the slider beam. The LCD display shows real-time values for battery voltage, current, resistance, and power.

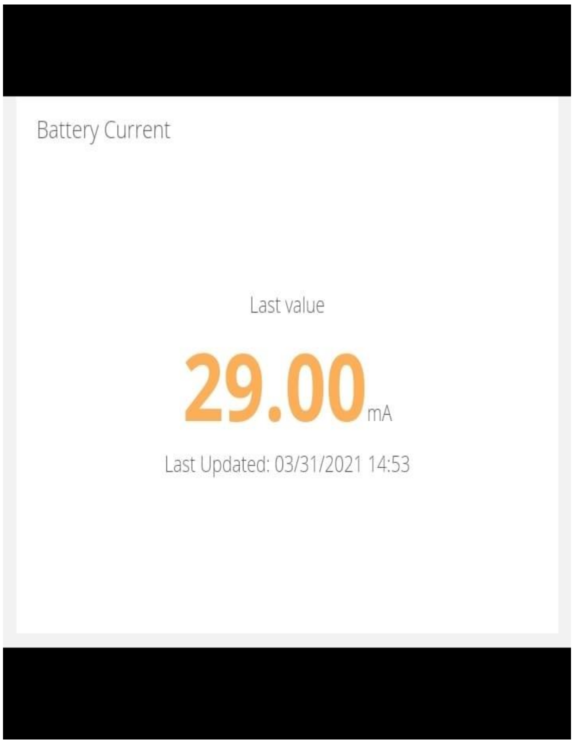

Fig:7: Battery Current value display

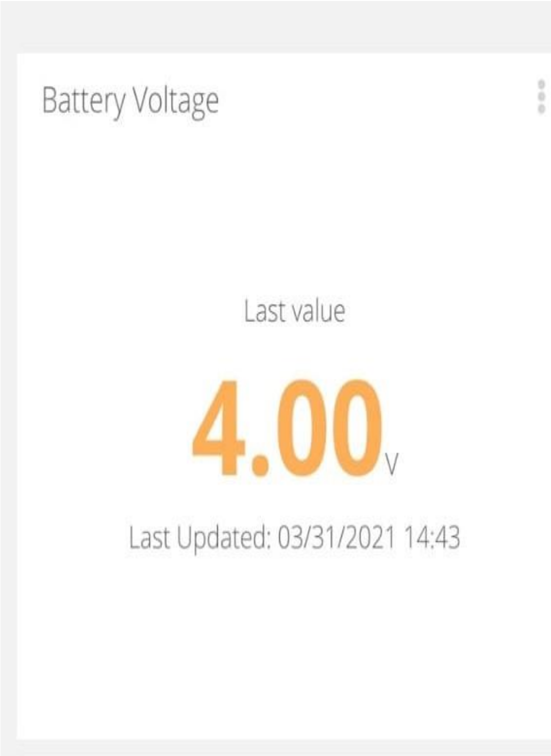

Fig 8: Battery Voltage value display

Real time kit has implemented with LCD display, Li-Ion batteries and also connected Arduino Microcontroller. The DC motor also connected with the microcontroller. 12V battery connected to give the input supply to this circuit. Bar code enabled for identification the location GPS included in this circuit.

The embedded system that employs devices able to operate the system is built on the language platform, which is mostly where real-time operations are executed. Manufacturers create embedded software for electrical equipment such as automobiles, telephones, modems, appliances, and so on. Lighting controls operated on an 8-bit microcontroller can be used as embedded system software. It may also be complex software for missiles, process control systems, and airplanes, among other things.

TABLE 1:

OUTPUT VALUES

SL.NO	VOLTAGE	CURRENT
1	4V	29MA
2	7.34	1A

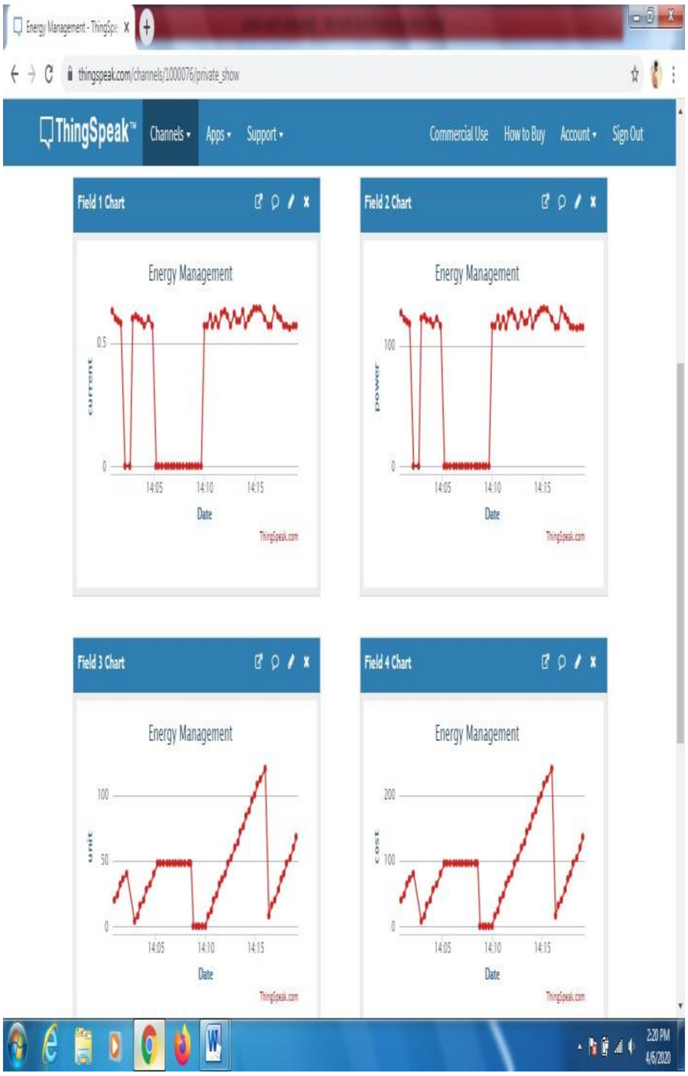

Fig 9: Signal Flow of Current, Power, Unit, and, Cost

This chart illustrates the energy management outcomes for an electric vehicle (EV), with data varying based on the battery charge level. The graph shifts in real-time as the EVs battery status is monitored. As technology progresses toward smart solutions, IoT and wireless systems will become more dominant. This system, being IoT- and cloud-based, is already wireless and thus well-suited for future adoption.

Currently, this setup provides parking and charging options based on the vehicle type. If EVs become the standard, the system can be easily adapted so that all slots offer charging. Standardizing EV charging will increase convenience further. This system can also integrate mobile applications with features like GPS, allowing users to book, pay, and manage parking or charging, adding even more "smart" functionality.

IoT embedded systems combine hardware, firmware, and internet connectivity to enable specific functions. These devices provide real-time data online for various tasks, such as monitoring, tracking, analysis, and even automated intervention

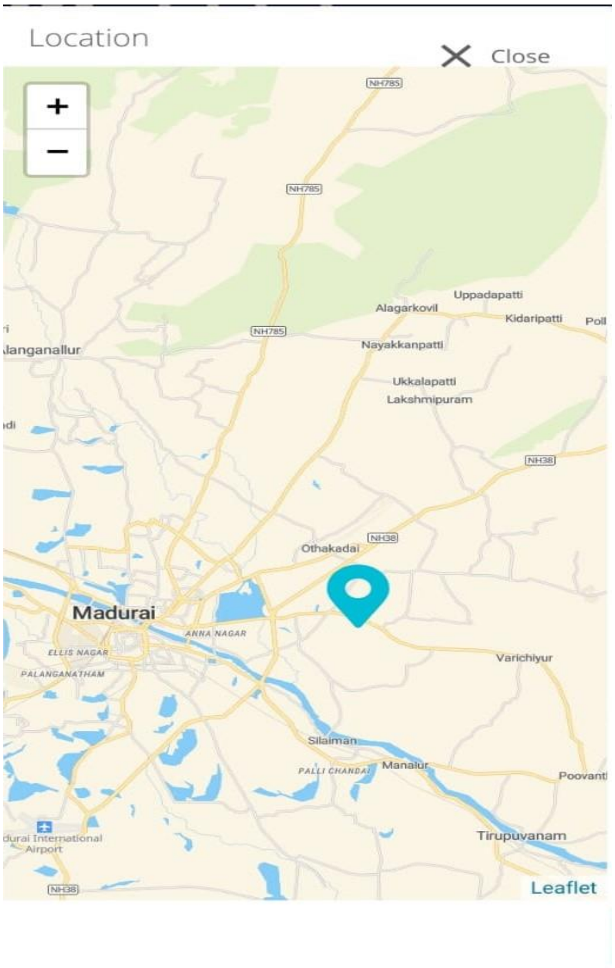

Fig No. 10: Location Tracking

The proposed approach enables efficient monitoring and control of various specific EV components, offering flexibility and ease of use for end users. With the integration of GPS, users can easily track the location of the electric vehicle (EV).

V. CONCLUSION

The project outlines the design and development of an IoT-based battery monitoring system for electric vehicles (EVs) to track battery performance degradation in real-time. The aim is to demonstrate the feasibility of this concept. The system includes the creation of hardware for the battery monitoring device and a web-based user interface for monitoring battery status. It can display information such as location, battery condition, and time by incorporating a GPS system to determine coordinates, which are then shown on the Google Maps application. Further enhancements to the system can include adding additional features. A smartphone application could be developed to help users monitor the battery and receive alerts for battery degradation. To improve the internet connection, Ethernet could be utilized for a more stable connection compared to GPRS.

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