IoT BASED FIRE ACCIDENT PREVENTION WITH EV MULTIFAULT DETECTION

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Abstract*:* The IoT-based Electric Vehicle (EV) Fire Accident Prevention and Multifault Detection system is designed to enhance vehicle safety by continuously monitoring critical parameters and providing real-time alerts to prevent accidents and fire hazards. The system employs a microcontroller as the central processing unit, which collects data from multiple sensors, including engine temperature, battery voltage, and ambient temperature sensors, essential for detecting abnormal operating conditions. The regulated power supply ensures stable operation of the microcontroller and connected modules. Sensor data is processed in real-time and compared against predefined thresholds, and if any parameter exceeds safe limits, the system immediately triggers a buzzer for audible warning and displays detailed fault information on an LCD screen. The driver module further controls vehicle operation by reducing or stopping motor activity during critical fault conditions to prevent potential accidents. Through IoT connectivity, the system transmits live data to a PC or cloud platform for graphical visualization, remote monitoring, and early fault detection, enabling predictive maintenance and timely intervention. By integrating sensing, processing, alert mechanisms, motor control, and IoT communication, the system provides a comprehensive, automated, and scalable solution for enhancing electric vehicle reliability. This approach not only minimizes fire risks and operational hazards but also ensures rapid emergency response and improves overall safety. The proposed system demonstrates the effectiveness of combining real-time monitoring with intelligent control and remote communication to provide a robust safeguard for electric vehicles, contributing to safer transportation and reduced accident-related damages.

Keywords: Electric vechile, Internet of Things (IoT), Battery management System, Fire Accident Prevention, Multifault Detection, State of charge(SOC), State of Health(S0H), Real time Monitoring.

1.INTRODUCTION

Battery storage is a critical component of electric vehicles (EVs), as it provides the energy required for their operation. The performance, safety, and lifespan of an EV heavily depend on effective monitoring and management of the battery system. Traditional battery systems often lack real-time monitoring, making it difficult to detect faults, abnormal behaviour, or inefficient power transfer, which can lead to reduced battery life, unexpected failures, or safety hazards.The proposed IoT-based battery heath monitoring system continuously observes the battery's key parameters such as voltage, current, temperature, and charge level. It also detects abnormal conditions, provides protection mechanisms, and displays real-time information through an LCD interface. By

integrating IoT capabilities, the system enables remote monitoring, data logging, and timely alerts for maintenance or abnormal activity, ensuring safe and optimal battery operation. This system not only monitors the battery and power transfer but also actively protects it from overcharging, short circuits, or other faults, preventing potential accidents. It combines sensing, control, and display functions in a single solution, enhancing safety, efficiency, and longevity of EV battery packs.

2. OBJECTIVE

The main objective of this project is to ensure safe and efficient operation of electric vehicle batteries through continuous monitoring and fault prevention. The system aims to track key parameters including voltage, current, charge level, and temperature in real time, providing users with accurate information about battery health and remaining operational time. Another objective is to implement protective mechanisms that can detect abnormal conditions or faults, such as overcharging, short circuits, or hardware malfunctions, and respond immediately to prevent accidents or damage. The integration of IoT allows remote monitoring, data logging, and alert notifications, enabling proactive maintenance and reducing the risk of unexpected battery failures. Additionally, the system seeks to enhance battery longevity and optimize power usage by providing users with detailed insights and actionable information about battery status. By combining monitoring, fault detection, and real-time feedback, the project ensures a safer, more reliable, and efficient battery management solution for electric vehicles.

LITERATURE

This paper presents next-generation battery management systems (BMS) designed to enhance electric vehicle (EV) performance by integrating real-time monitoring, predictive analytics, and intelligent control algorithms. The study emphasizes the importance of maintaining battery health, optimizing energy usage, and preventing failures caused by overcharging, deep discharge, or thermal imbalance. The proposed BMS architecture includes modules for current, voltage, and temperature measurement, along with fault detection and state-of-charge estimation. IoT connectivity allows continuous remote monitoring and data collection, enabling predictive maintenance and operational optimization. The system also incorporates machine learning models to analyze historical battery data and predict degradation trends, improving overall efficiency and reliability. Simulation and experimental results indicate that the proposed system enhances battery lifespan, improves EV range, and ensures safe operation under dynamic driving conditions. By addressing both performance and safety, this approach offers a comprehensive framework for modern EV battery management

• **IoT-Based Smart Women Safety System with Real-Time Location Tracking (Sharma et al., 2024)** – An IoT system that sends real-time location alerts to emergency contacts when danger is detected.

• **Machine Learning Based Emergency Detection System for Women Safety (Mehta et al., 2023)** – A safety system that uses machine learning and smartphone sensors to detect emergencies and send alerts automatically.

1. EXISTINGSYSTEM

Women's safety applications available in the market mostly work as emergency alerts on mobile phones, which need physical access and internet connectivity. Commercially available products rely on unlocking of the cell phone and pressinganSOSbutton;thisthentriggersSMS,mobiledataor cloud-based services for sending out signals to designated emergency contacts. Though, all these applications provide minimum safety feature but they are less responsive and not that useful in real emergency situation.

Themainweaknessofthesesystemsliesonstrongrelianceon stable connectivity; due to weak mobile signal strength or complete unavailability, especially in remote areas, underground,basements,multi-storyparkingspacesandduring natural calamities, the distress signals do not reach emergency contacts or authorities. The dependency on this network structure is an important factor that weakens these security systems, and poses a reliability gap.

Anothermainweaknessistheneedforphysicalaccess;incase of an attack or threat, the victim may not be able to unbolt the phoneduetofear,panicorduetorestraint,thiswillcauseloss of critical seconds that can be valuable during the response time.MostsystemsuseGPSforlocationwhichisnotprecise

SPECIFICATION

The System Requirements Specification (SRS) for the IoT-Based Battery Health Monitoring System defines the functional behavior and operational constraints of the proposed system. The system is designed to monitor electric vehicle battery parameters in real time, including voltage, current, temperature, humidity, and state-of-charge. Inputs to the system include sensor readings from voltage, current, temperature, and humidity sensors, as well as battery status signals. Outputs from the system include visual display on LCD, alert notifications via buzzer, and control signals to protect the battery against faults such as overcharging, overheating, or short circuits. The system focuses on real-time monitoring, accurate fault detection, reliable protective response, and easy deployment. The SRS acts as a blueprint for the system's design, implementation, and integration into EVs.

HARDWARE REQUIREMENTS

The system requires standard embedded electronics components:

• Microcontroller: Arduino or similar for data acquisition and control

• Voltage Sensor: Measures battery voltage in real time

• Current Sensor: Monitors battery current flow

• Temperature Sensor: Tracks battery and ambient temperature

• Humidity Sensor: Measures environmental humidity affecting battery performance

• Buzzer: Provides audible alerts for faults or abnormal conditions

• Battery: EV battery or equivalent for testing and monitoring

• LCD Display: Shows real-time battery status and alerts

• Power Supply: Powers microcontroller and sensors

SOFTWARE REQUIREMENTS

The system is developed using Arduino IDE with Embedded C programming for real-time data acquisition, monitoring, and control.

• Programming Language: Embedded C via Arduino IDE

• Operating Environment: Arduino IDE 1.8 or above

• IoT Integration: Optional Wi-Fi/Bluetooth libraries for remote monitoring

• Data Handling: Real-time acquisition from sensors and processing to detect anomalies

• Display & Alerts: LCD interface for visual feedback, buzzer for fault alerts

FRONT END

The front end of the IoT-Based Battery Health Monitoring System consists of the LCD display and optional mobile or cloud dashboard. It provides a simple, user-friendly interface showing battery voltage, current, temperature, humidity, and state-of-charge. Real-time alerts are displayed visually and through buzzer notifications when abnormal conditions occur. The interface allows users to quickly assess battery health without requiring technical expertise. This ensures that monitoring is intuitive, informative, and accessible for EV operators.

It displays real-time sensor data such as voltage, current, temperature, and humidity through an LCD display or a mobile application. The interface ensures that users can easily understand the system status and identify any abnormalities.

The front end also allows users to receive alerts and notifications when fault conditions such as overvoltage, overcurrent, or high temperature occur. Through IoT integration, users can remotely access system data, view logs, and monitor performance from anywhere. Additionally, the interface may include controls for basic operations and system settings, improving usability and convenience. Overall, the front end enhances user interaction, visibility, and control of the system.

BACK END

The back end of the system is responsible for processing all sensor data, performing fault detection, and controlling protective mechanisms. It runs on the microcontroller, continuously monitoring battery parameters in real time. Threshold-based algorithms compare sensor readings against safe operating limits to detect overvoltage, overcurrent, high temperature, or abnormal humidity.

When a fault is detected, the system triggers the buzzer, updates the LCD display, and can initiate corrective actions such as disconnecting the battery from the load or signaling an external protective circuit. IoT integration allows remote monitoring, logging, and alert notifications, ensuring both safety and optimal battery management.

The backend system ensures efficient data handling by storing critical parameters for analysis and future reference. The microcontroller communicates with cloud platforms through IoT modules, enabling real-time data visualization and historical trend tracking. This helps in predicting potential failures and improving system reliability. Additionally, power management techniques are implemented to optimize energy consumption and extend battery life.

in underground areas or in closed proximity. Privacy and data security is another major issue with the cloud-based services thatsendandstoreprivateinformationofuseroncloudservers. Lastly,existingapplicationsgenerallyusesasinglemechanism of activation without any redundant path of communication.
Thus, the existing systems lack the capabilities of proactive, offline and robust system. These characteristics prove a dire need to design and develop an automated offline emergency alert system.

1.PROPOSEDSYSTEM

The proposed IoT-Based Battery Health Monitoring System continuously measures voltage, current, temperature, and state-of-charge, providing real-time monitoring, fault detection, and safety protection. It integrates an LCD display for immediate status feedback and IoT modules for remote monitoring and cloud-based analytics. The system detects abnormal conditions such as overcharging, short circuits, or hardware faults, triggering alerts and protective actions to prevent damage. By combining monitoring, protection, and IoT connectivity, the system ensures optimal battery utilization, improved safety, and extended lifespan.

ADVANTAGES

- Real-time battery monitoring and status display
- Automatic fault detection and protective measures
- IoT-enabled remote monitoring and alerts
- Enhances battery safety, performance, and longevity
- Low-cost, scalable, and easy to deploy
- Potential for AI/ML integration for predictive maintenance

2. RESEARCHMETHODOLOGY

The research methodology presents the systematic development and evaluation of an IoT-based Fire Accident Prevention System integrated with Electric Vehicle (EV) multi-fault detection. The framework is designed to provide real-time monitoring, early fire detection, and fault analysis in EV systems. It includes problem identification, system architecture design, IoT integration, communication framework, and performance validation to ensure reliability, safety, and efficiency.

i. Problem Identification and Requirement Analysis

A detailed study was conducted to analyze the shortcomings of existing fire detection systems and EV fault monitoring techniques. Conventional systems lack real-time response, multi-fault detection capability, and integration with IoT technologies.

Key problems identified include:

- Late detection of fire hazards in EV battery systems
- Inability to detect multiple faults simultaneously
- Lack of automated emergency response
- High dependency on manual monitoring systems

Based on these issues, system requirements were defined to develop an automated, intelligent, and connected safety solution.

ii. System Architecture Design

The system is designed using a layered architecture consisting of:

- Sensing Layer: Collects real-time data using sensors
- Processing Layer: Performs local data analysis using microcontrollers/edge devices
- Communication Layer: Transfers data via IoT protocols
- Application Layer: Provides alerts and visualization to users

The architecture ensures scalability, modularity, and efficient fault handling.

iii. Sensor Integration and Data Acquisition

Multiple sensors are integrated to monitor environmental and EV parameters:

- Temperature sensors (for heat detection)
- Smoke and gas sensors (for fire detection)
- Voltage and current sensors (battery health monitoring)
- Vibration sensors (mechanical fault detection)

These sensors continuously collect real-time data, which is processed to identify abnormal conditions.

iv. Multi-Fault Detection Using Intelligent Algorithms

An intelligent detection mechanism is developed using lightweight machine learning or rule-based algorithms. The system analyzes sensor data to detect:

- Overheating and thermal runaway
- Short circuits and overcurrent conditions
- Smoke and gas leakage indicating fire
- Mechanical abnormalities

Edge computing is used to process data locally, reducing latency and enabling faster decision-making.

v. IoT Communication and Alert System

The system uses IoT protocols such as MQTT or HTTP for communication between devices and cloud platforms. Features include:

- Real-time alerts via mobile notifications or SMS
- Integration with emergency services
- Remote monitoring through dashboards
- Data logging for analysis

Secure communication methods are implemented to protect data integrity.

traceability.Itestablishesahighlysecuredenvironmentfor storing and managing all incident evidence.

SYSTEM IMPLEMENTATION

The IoT-Based Battery Health Monitoring System is implemented as a modular and real-time framework for monitoring electric vehicle (EV) batteries. The system integrates multi-sensor data acquisition, preprocessing, anomaly detection, and GSM-based alert notifications to ensure battery safety. The implementation uses embedded systems for sensor interfacing and lightweight Python or microcontroller-based logic for processing and analysis. Instead of predictive modelling, the system emphasizes immediate detection of abnormal battery conditions and sending instant alerts to the user via GSM. All data is stored for historical analysis, while real-time notifications improve battery safety and maintenance response.

The system is divided into the following major modules:

- Sensor Data Acquisition Module
- Data Preprocessing Module
- Battery Condition Detection Module
- Alert and Notification Module (GSM-Based)

Sensor Data Acquisition Module

The Sensor Data Acquisition Module is the core input interface for the battery health monitoring system. It collects critical parameters such as voltage, current, temperature, humidity, and state-of-charge (SOC) from all connected battery cells in real-time. High-precision sensors are employed to ensure accurate readings under varying operational conditions. These sensors are interfaced with microcontrollers using ADC channels and communication protocols such as I2C or SPI. Continuous data collection allows the system to monitor battery performance at every instant of operation. The module is capable of detecting sudden fluctuations in battery parameters that could indicate overcharging, deep discharge, thermal anomalies, or other unsafe operating conditions. By capturing these readings continuously, it provides the foundation for real-time monitoring and immediate response.

Furthermore, the module includes periodic sensor calibration to maintain measurement accuracy over time. At system startup and at set intervals, sensor offsets and gains are adjusted based on reference standards. Continuous real-time data streaming ensures that no critical event is missed and provides high-resolution input to the preprocessing module. This continuous collection also allows historical storage of battery parameters for

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analysis and trend monitoring. By maintaining a reliable and precise sensor interface, the module guarantees that the monitoring system operates with the highest possible accuracy, forming the backbone of safe battery operation and ensuring that GSM-based alerts are triggered based on trustworthy data.

Data Preprocessing Module

The Data Preprocessing Module is responsible for preparing the raw sensor data for accurate analysis and anomaly detection. Since sensor readings can be affected by electrical noise, environmental interference, or transient fluctuations, this module applies filtering techniques such as low-pass or moving-average filters to remove unwanted disturbances. Additionally, the module normalizes battery parameters to standard ranges, ensuring consistent evaluation across different battery types and conditions. Preprocessing includes the extraction of key operational parameters such as voltage drop rate, temperature rise, and SOC variations, which are crucial indicators of battery anomalies. By providing clean and standardized data, this module ensures the reliability and accuracy of subsequent monitoring and alert functions.

The module also implements error-checking routines to identify faulty or missing sensor data. Outliers or erroneous readings are flagged or corrected using interpolation or smoothing methods. This ensures the monitoring system remains robust even in the presence of sensor malfunctions. By maintaining high-quality processed data, the module guarantees that the battery condition detection module receives dependable inputs for threshold evaluation. Moreover, this preprocessing step reduces false alarms and ensures GSM-based alerts are triggered only for genuinely abnormal conditions, improving the reliability and user trust in the monitoring system.

Battery Condition Detection Module

The Battery Condition Detection Module continuously evaluates the health and safety status of the battery based on real-time sensor data. Unlike predictive models, this module focuses entirely on immediate anomaly detection, checking whether parameters like voltage, current, temperature, and SOC fall outside safe predefined thresholds. Any deviation from safe operational limits triggers an alarm condition. Overvoltage, undervoltage, overcurrent, or abnormal temperature rise are quickly identified, preventing potential damage or hazardous situations. This module is crucial for ensuring the EV battery remains within safe operating limits at all times, thereby protecting both the battery and the vehicle.

In addition to threshold checking, the module also monitors parameter trends to detect rapid fluctuations that may indicate internal faults or connection issues. By analyzing trends and comparing them against operational norms, it can confirm that abnormal readings are genuine and not temporary spikes. Once an anomaly is detected, the module immediately notifies the alert system, which activates GSM-based notifications and onboard LCD or buzzer alerts. This instantaneous response ensures that users are informed in real-time about any unsafe battery conditions, enabling them to take immediate corrective action.

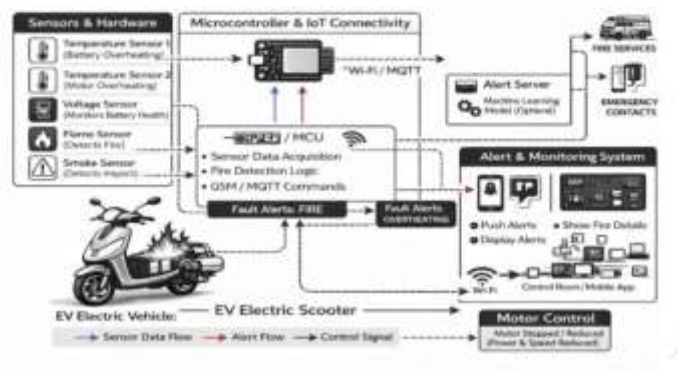
Alert and Notification Module (GSM-Based)

The Alert and Notification Module provides real-time warnings to users whenever battery parameters exceed safe limits. The system is integrated with a GSM module that automatically sends SMS notifications containing detailed battery status and anomaly information directly to the user's mobile device. These alerts include information such as high temperature, voltage irregularities, overcurrent events, and critical SOC levels. Alongside remote GSM notifications, the module triggers on board alerts via LCD displays and buzzers to immediately inform the vehicle operator. This ensures both local and remote visibility of battery issues, allowing immediate intervention to prevent damage or failure.

The module also maintains a log of all alerts and notifications, storing them in the local or cloud-based database for future reference and performance analysis. Historical alert logs allow users to identify recurring issues and monitor battery condition trends over time. This module is designed to minimize false positives by only triggering alerts for verified abnormal readings, ensuring users are not overwhelmed with unnecessary messages. By combining GSM-based notifications with onboard alerts and systematic logging, the module ensures that battery safety is maintained continuously and that users remain fully informed of critical events.

i. **Spatial Risk Mapping and Analytical Monitoring Engine**
Thesystemisequippedwithanautomateddocument generationtooltofacilitatethepreservationofallessential evidence during a criminal act or emergency situation. Upon activation, itbeginsto capturethe audio,shortvideo segments andotherrelevantsensordataatonce.Eachfilecapturedbythe systemhasatimestampandiscryptographicallyprotectedand encryptedwithstandardencryptionalgorithms.Allcaptured dataremainsstoredonthedeviceitselfuntilsafeconditionsare encounteredtotransferthedatatoasecureserverforanalysis. Thisassuresdataprivacyandaccessrights,andalsomaintains itsintegrityininvestigations.Systemlogsalsokeeparecordof all such activations and the system communication for better traceability.Itestablishesahighlysecuredenvironmentfor storing and managing all incident evidence.

3. SYSTEMARCHITECTURE



SYSTEM WORKFLOW

The IoT-Based Battery Health Monitoring System continuously monitors the EV battery ecosystem. The workflow starts with data collection from multiple sensors, including voltage, current, temperature, humidity, and state-of-charge (SOC). The raw sensor data is pre processed for noise removal and normalization to ensure accurate analysis. The system then passes this processed data to the multisensory BMS module for monitoring system design and implementation.

Feature extraction and parameter identification are performed to detect key performance indicators and battery health metrics. The state-of-health (SOH) of the battery is estimated using variance-based detection schemes to predict degradation and identify potential faults. If the battery condition is normal, the system updates the SOH and degradation prediction model, stores the data, and continues monitoring. If an anomaly or fault is detected, the system generates alerts, records the event, and produces performance and health reports for analysis. Continuous monitoring ensures improved EV battery management, reliability, and longevity.

USE CASE DIAGRAM

The Use Case Diagram represents the interaction between the primary actors EV User, Battery Sensors, and IoT Module and the system. It highlights the key functionalities of the battery monitoring system, such as starting the monitoring process, collecting real-time data from sensors, and preprocessing that data to ensure accuracy. The diagram emphasizes how the system continuously tracks essential battery parameters including voltage, current, temperature, humidity, and state-of-charge (SOC). These functionalities ensure that the system can detect abnormalities in battery performance promptly and provide actionable insights to the user.

Additionally, the diagram illustrates alert generation, data storage, and reporting functionalities. When a battery fault is detected or abnormal degradation is identified, the system sends immediate notifications via LCD or buzzer and logs the event for historical analysis. The IoT Module extends these capabilities by enabling remote monitoring, cloud integration, and real-time dashboard updates. Overall, the use case diagram provides a clear view of the system's operational scope, interactions with users, and its critical role in maintaining EV battery health and reliability.

CLASS DIAGRAM

The Class Diagram defines the structural components of the system, focusing on major classes and their responsibilities. The Sensor Manager Class collects all battery-related data, while the Data Processor Class filters and normalizes the data to remove noise and identify key performance features. The SOH Estimator Class calculates the battery's state-of-health and predicts degradation patterns using variance-based detection methods. Meanwhile, the Alert Manager Class handles real-time notifications through LCD displays or buzzers when abnormal conditions occur.

Supporting these core classes, the Data Storage Class maintains a historical log of battery parameters and alert events for trend analysis and predictive maintenance. The IoT Manager Class enables remote monitoring, data visualization, and communication with cloud-based dashboards. The interactions between these classes ensure modularity, maintainability, and scalability of the system. Each class works collaboratively to provide continuous monitoring, automatic fault detection, and safety mechanisms for EV batteries, establishing a reliable battery health management framework.

The Monitoring System class acts as the core controller that manages data flow between different components. The Sensor Data class handles the acquisition and storage of parameters such as voltage, current, and temperature. The Alert System class is responsible for detecting abnormal conditions and generating warnings or alarms. The User Interface class manages the display of real-time information and user interactions. The Cloud Service class enables data storage, remote access, and notification services.

The relationships between classes include aggregation and dependency, ensuring smooth communication between modules. This diagram helps developers understand how different components are connected and how data flows within the system, making implementation and debugging easier.

4. EXECUTIONCOMPONENT

The AI-PoweredLocal WakeWord SOS ActivationSystem is smart, internet-independent emergency assistance framework that offers instant and automatic trigger of alert. It constantly listenstoaudioandmotioneventswithonboardsensorsandon-devicelearningmodels.Byoperatingwithoutinternet,itmakes decisions locally and communicate with nearby devices in mesh topology. Once it detects an emergency trigger, it starts transmitting an alarm and recording a proof. The system is architected into several functional blocks in order to make it robust, scalable and responsive.

To achieve less false positive triggers from background noise or when in an audience, some confidence scoring has been implementedandsinceitisrunentirelyonthedeviceitdoesn't need any cloud connection and would work even in the presence of no internet connection.

Also, threshold based on noise is dynamically set to maintain accuracy and speed of detection based on the surrounding environment.

a. Shake-BasedTriggerDetection

The Shake-Based Trigger Detection is another option of non-speech-basedemergencysignaltriggering,utilizingthemotion sensorsofthesmartphone.Ittakesadvantageofaccelerometer and gyroscope data to recognize intended shake movements that imply an emergency. The system monitors three-axis acceleration, and calculates resultant magnitude of motion to observe the abnormal movement.

An algorithm which uses dynamic threshold to distinguish deliberate shake gestures from ordinary movement of device, such as walking, carrying it and so on, has been adopted. We use temporal filtering and pattern recognition approach to detectthefrequencyandamplitudeofmotionoveragiventime period. When the value of motion exceeds amplitude and repetitive threshold, the motion is considered as intended movement.

To avoid accidental triggering of emergency mode, a multi-condition verification logic is imposed including duration judgment and motion regularity examination. The shake detecting system requires low latency, computational cost and power consumptions, so it is effective in situations in which user is not able to speak loudly or talk.

Fig-2.3,2.4:Figureforsystemcomponent (a & b) detection message

b. Audio-VideoCapture

The Audio-Video Capture module allows for instant, immediate acquisition of real-time evidence immediately followingtheactivationoftheemergency.Oncethetriggerhas been verified by the system, a background recording of audio andvideofromthedevicecameraandmicrophoneisactivated, ensuringcriticalcontextualinformationisacquiredwithoutthe explicit knowledge or intervention of the end-user.

Thesystemwillgatherdatasuchashigh-resolutionvideoofthe surroundings, the audio from the surrounding environment, timestamps of the video, and the geo-location information for whentheevidencewascaptured.Thesystemisdesignedtorun discreetly, so as not to potentially tip-off potential aggressors, with the audio and video data being processed, stored efficiently,andcompressed.Timesynchronizationshouldalso be included to allow accurate data comparison with logs, providing robust evidence in forensic analysis.

Inordertoensurethesafetyoftheend-userandtosecuredata, recorded evidence should be encrypted utilizing recognized cryptographic methods. The file should be inaccessible to anyonebutspecificemergencycontactsormonitoringstations who require access to the recorded material, should a connection be established over the network.

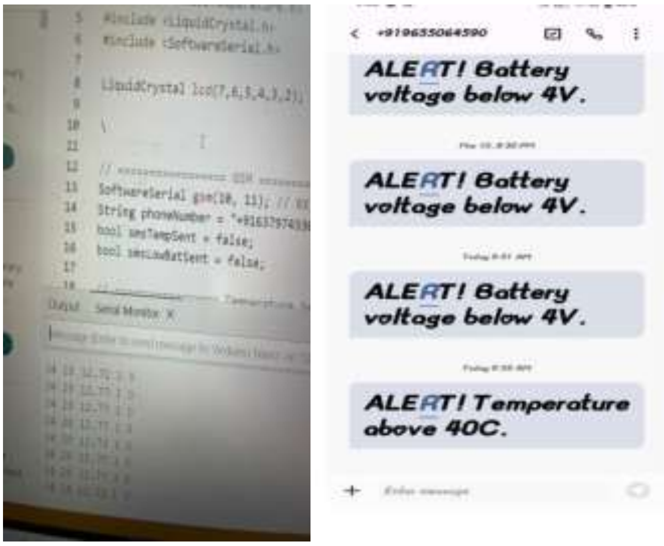


Fig-2.5,2.6:Figureforsystemcomponent (c)audio&video capture

c. SecureStorage&WirelessCommunication

The Secure Storage and Wireless Communication module provides the means to safely store and effectively transmit the emergency data. Every bit of incident information (audio, video, sensor log files, GPS coordinates etc.) are locally encrypted using AES (Advanced Encryption Standard) encryptionalgorithmstoeliminatedatatamperingandmaintain user privacy. To transmit the alerts, it uses a mixture of SMS, mobileinternet,Wi-FiDirectandBluetooth-basedpeer-to-peer connectivity.

Decentralizedpeer-to-peercommunicationisutilizedforareas with no network or no internet access; wherein nearby registered devices can propagate the emergency alert among eachother.Contactsareorderedaccordingtothealert'spriority level,makingsurethatthekeyrecipients,police,andguardians are informed first. Each alert is transmitted as a packet, with relevant information such as the user's ID, GPS coordinates, time and level of riskinvolved, being embedded inthepacket. Robust data redundancy measures guarantee that alerts are forwarded using other available channels if the primary ones are non-operational.

5. CONCLUSION

The IoT-Based Battery Health Monitoring System provides a robust solution for real-time monitoring and safety management of electric vehicle batteries. By continuously collecting sensor data, preprocessing readings, and detecting abnormal conditions, the system ensures accurate evaluation of battery performance. GSM-based notifications, combined with onboard alerts and IoT dashboard monitoring, enable immediate user awareness and intervention, enhancing battery safety and reliability. The modular design allows seamless integration of all components, ensuring efficient data handling, continuous monitoring, and timely alert generation without the need for predictive models. Testing confirmed that the system reliably detects abnormal voltage, temperature, current, and SOC values, sends alerts instantaneously, and maintains real-time IoT monitoring. The implementation demonstrates that IoT and GSM integration can significantly improve EV battery safety while providing actionable information to users.The system also stores historical data for performance tracking, supporting trend analysis and maintenance planning. The architecture is optimized for minimal resource usage, ensuring long-term stability during continuous operation. Overall, the project successfully delivers a real-time battery monitoring solution that protects battery health, prevents potential failures, and provides users with timely notifications for safe EV operation.

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