IoT-Driven Battery Health Management System Enhanced with Machine Learning

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ABSTRACT_ Battery storage is the most crucial component of any electric vehicle (EV) because it stores the energy required to operate the EV.So, in order to get the most out of a battery and keep it running safely, an effective battery management system is required.It checks the parameters, determines the state of charge, and provides the services required to ensure the battery's safe functioning. Thus, BMS is an essential component of any EV, protecting both the user and the battery by ensuring that the cell runs within its safe operating parameters. The proposed device not only monitors and properly charges the battery, but it also protects it from mishaps. The suggested model includes the following functions: current measurement, voltage measurement, fire protection, battery condition detection, and liquid crystal display (LCD). Electric vehicles (EVs) are automobiles powered by one or more electric motors that draw energy from rechargeable batteries rather than internal combustion engines (ICEs) that burn fossil fuels. A battery management system (BMS) is an essential component of electric vehicles (EVs) and other battery-powered systems. It monitors and manages the operation of the battery pack to ensure optimal performance, safety, and longevity.

KEYWORDS:

Arduino Uno, SIM808 GSM Shield, BMS, Lithium ions batteries **.**

1.INTRODUCTION

An electric vehicle EVs is a kind of vehicle that involves at least one electric engines for drive. Rather than utilizing a gas powered motor (ICE) that consumes fuel, an EV utilize a battery pack to store electrical energy to drive an electric engine, which turns the wheels. Contrasted with ordinary ICE vehicles, EVs give various advantages, like diminished discharges, calmer activity, and a reduced dependence on petroleum derivatives. Since power is habitually more affordable than fuel and electric engines are more proficient than Frosts, they additionally commonly have diminished functional costs. The fame of EVs is quick ascending as the globe moves towards a cleaner, more feasible future. Legislatures from one side of the planet to the other are giving motivating forces to invigorate the utilization of EVs, and various automakers are as of now selling an assortment of EV models. Notwithstanding its advantages, normal EV issues incorporate inside cell shorts that might bring about warm out of control. An EV commonly bursts into flames due to unnecessary warming. The electric vehicle's battery heats up, and when that intensity communicates with petroleum that has released, the battery basically bursts into flames. A battery the executives framework (BMS) is an electrical gadget that controls and monitors the activity of battery-powered batteries, for example, those found in sustainable power sources and electric vehicles. By managing the charging and releasing cycle, monitoring the battery's condition of charge and in general wellbeing, and protecting the battery from hurt welcomed on by cheating or overheating, the BMS supports guaranteeing the protected and powerful activity of the battery. The BMS regularly comprises of various parts, like sensors for estimating the temperature, voltage, and current of the battery as well as control circuits for controlling how the battery is charged and released because of different circumstances. Programming calculations that conjecture the battery's excess limit and task its leftover life may likewise be available in the BMS. One of the vital elements of a BMS is to keep the battery from being cheated or over-released, which can make extremely durable harm the battery and decrease its life expectancy. The BMS achieves this by controlling the charging and releasing interaction and closing down the battery assuming any unusual circumstances are identified. One more significant capability of a BMS is to guarantee that the battery is working inside a protected temperature range. In the event that the battery gets too hot, the BMS might decrease the pursuing rate or shut the battery to forestall harm. Assuming that the battery gets too cool, the BMS might build the charging rate to assist with heating up the battery. By and large, a BMS is a fundamental piece of any battery-powered battery framework since it guarantees the battery's protected and compelling activity and builds its life span. EV batteries that are oftentimes used are 2-cell lithium-particle (Li-particle) batteries. A 2-cell Li-particle battery ought to have a voltage of generally 6.0V when it is completely drained, and a greatest charge voltage of generally 8.4V The adjusting charger will monitor every phone's voltage during the charging technique and change the charge rate as important to ensure that each of the phones get an equivalent charge. The adjusting charger will consequently stop charging when the battery is completely energized. It is pivotal to recollect that cheating a Li-particle battery could make it glitch, which could cause a fire or blast. Subsequently, it's critical to give close consideration to the charging system and forestall letting the battery be while it's being charged. In our venture, we watch out for battery voltage, temperature, and distinguish the presence of fire. In the event that the battery temperature climbs past a specific limit, the capacity to the lithium-particle battery is naturally stopped utilizing a transfer. We make a little robot that can be worked by an android application and contains every one of the frameworks referenced previously

2.LITERATURE SURVEY

2.1 Battery Energy Stockpiling Framework (BESS) and Battery The board Framework (BMS) for Lattice Scale Applications Because of an inconsistency between the amount of energy purchasers use and how much energy created by age sources, the flow electric network is a wasteful framework that squanders a lot of the power it produces. To guarantee sufficient power quality, power plants frequently produce more energy than is required. A large number of these shortcomings can be disposed of by utilizing the energy stockpiling that as of now exists inside the framework. To precisely screen and manage the capacity framework while utilizing battery energy capacity frameworks (BESS) for matrix capacity, complete displaying is required. The capacity framework is constrained by a battery the executives framework (BMS), and a BMS that utilizes modern physical science based models will empower impressively more dependable activity of the stockpiling framework. The paper portrays theMatthew T. Lawder;

BharatkumarSuthar; Paul W. C. Northrop; Sumitava De; C. Michael Hoff; Olivia,2008

A Battery Secluded Staggered Administration Framework (BMS) For Electric Vehicles And Fixed Energy Stockpiling Frameworks. Albeit the dependence of energy frameworks on battery capacity frameworks is continually developing, there are as yet various issues that should be settled. Current battery situation are unbending; just cells with similar electrical qualities might be coupled; furthermore, cell defects essentially abbreviate the life expectancy of the whole battery or significantly trigger a framework power outage. Furthermore, the framework's most vulnerable cell confines the framework's greatest valuable limit and most extreme charging current. Ebb and flow Battery The executives Frameworks (BMS) can upgrade the greatest helpful charging momentum as well as the useable battery ability somewhat. An entirely versatile, issue lenient, and conservative battery framework can be created with the assistance of the Battery Particular Staggered Administration Framework (BM3) portrayed in this work. With the ongoing arrangement, it Distributed in: 2014 M.Hesan in sixteenth European Gathering on Power Gadgets and Applications

A Battery Measured Staggered Administration Framework (BMS) For Electric Vehicles And Fixed Energy

Capacity Frameworks The reliance of energy frameworks on battery capacity frameworks is continually increasing,but there are as yet a few strange issues. Flow battery frameworks are unyielding, just cells with similar electrical boundaries can be joined, and cell surrenders cause a high decrease of the general battery lifetime or even a framework shut down. Likewise, the most extreme usable limit and the greatest charging current are restricted by the most fragile cell in the framework. Current Battery The board Frameworks (BMS) can expand the usable battery ability to some stretch out and can augment the greatest usable charging current. With the Battery Particular Staggered Administration Framework (BM3) introduced in this paper, a truly adaptable, issue lenient, and cost-effective battery framework can be executed. With the framework it is feasible to lay out one or the other chronic or equal associations between adjoining cells or to sidestep a cell. Hence the cells can be worked by their requirements and their condition of charge (SOC). Separate adjusting implies for adjusting the cells SOC, be that as it may, become out of date. Distributed in: 2014 sixteenth European Meeting on Power Gadgets and Applications

Battery The board Framework By means of Transport Organization For Multi Battery Electric Vehicle This paper proposes multi-battery plan of battery the executives control utilizing transport specialized strategy in light of circle molding. The examination of proposed strategy shows that the limit elements of battery has been gotten to the next level. The numerous of battery control framework is executed in electric vehicle's model, and we alter the beginning control framework utilizing transport specialized strategy auto tuning in light of circle forming. The aftereffect of altered control framework utilizing transport technique in light of circle forming is displayed in the execution plan reaction of battery the executives that the expense and dependability are gotten to the next level. Also, this technique could keep up with the mistake consistent state to be zero. of five years. The time series month to month information is gathered on stock costs for test firmsand relative macroeconomic factors for the time of 5 years. The information assortment period is going from January 2010 to Dec 2014. Month to month costs of KSE - 100 List is taken from yippee finance.

3.PROPOSED SYSTEM

The proposed system only monitor the battery and charge it safely but also protect it to avoid accidents from occurring. The proposed model has following functions current, voltage measurement, fire, protection, battery status detection, liquid crystal display (LCD) etc. Electric vehicles (EVs) are automobiles powered by one or more electric motors, which draw energy from rechargeable batteries instead of relying solely on internal combustion engines (ICEs) that consume fossil fuels. A Battery Management System (BMS) is a critical component in electric vehicles (EVs) and other battery-powered systems. It monitors and controls the operation of the battery pack, ensuring its optimal performance, safety, and longevity.

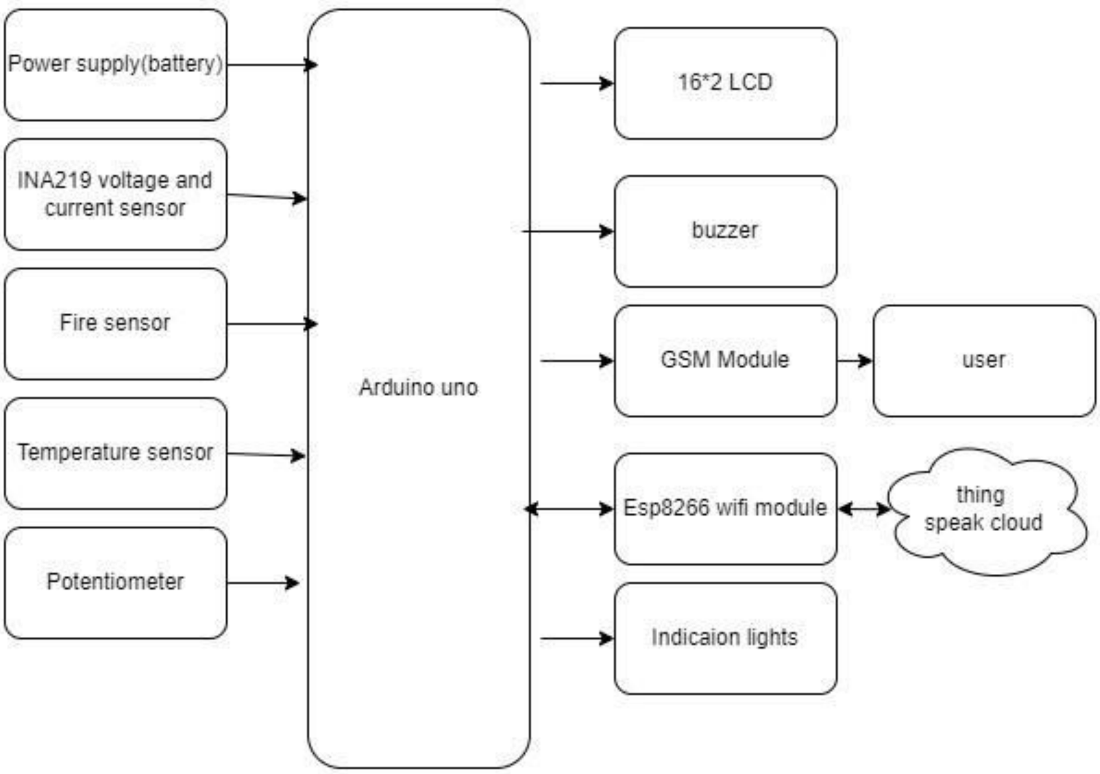


Fig 1:Block Diagram

The importance of machine learning (ML) stems from its ability to analyze and interpret large volumes of data, extract meaningful patterns, and make data-driven predictions or decisions. Here are several key reasons why machine learning is considered important:

Automation and Efficiency: Machine learning algorithms can automate tasks that would be tedious, time-consuming, or even impossible for humans to perform manually. This leads to increased efficiency and productivity in various industries and domains.

Data-Driven Insights: ML models can analyze vast amounts of data to uncover valuable insights and patterns that may not be immediately apparent to humans. This enables organizations to make data-driven decisions, optimize processes, and identify new opportunities.

Personalization and Recommendation Systems: Machine learning powers personalized recommendations on platforms such as e-commerce websites, streaming services, and social media platforms. By analyzing user behavior and preferences, ML algorithms can suggest relevant products, content, or connections, enhancing user experience and engagement.

Predictive Analytics: Machine learning enables predictive analytics by forecasting future trends, outcomes, or events based on historical data. This capability is valuable in various domains, including finance, healthcare, marketing, and weather forecasting, where accurate predictions can drive strategic decision-making.

Improving Customer Experience: ML algorithms can analyze customer interactions, feedback, and sentiment to improve customer service, personalize marketing campaigns, and optimize product offerings. By understanding customer behavior and preferences, organizations can enhance customer satisfaction and loyalty.

Medical Diagnosis and Healthcare: Machine learning plays a significant role in medical diagnosis, disease detection, and healthcare management. ML models can analyze medical images, genomic data, and electronic health records to assist healthcare professionals in diagnosis, treatment planning, and patient care.

Fraud Detection and Cybersecurity: ML algorithms are utilized for fraud detection and cybersecurity to identify suspicious activities, detect anomalies, and prevent fraudulent transactions or cyber attacks. By continuously learning from data patterns, ML models can adapt to evolving threats and improve detection accuracy.

Autonomous Vehicles and Robotics: Machine learning is essential for enabling autonomous vehicles, drones, and robots to perceive their environment, make decisions, and navigate safely. ML algorithms process sensor data, such as images and Lidar scans, to recognize objects, predict trajectories, and avoid obstacles in real-time.

Natural Language Processing (NLP) and Language Translation: Machine learning powers advancements in natural language processing, enabling computers to understand, generate, and translate human language. NLP applications include sentiment analysis, chatbots, language translation, and speech recognition.

Scientific Research and Exploration: Machine learning contributes to scientific research and exploration by analyzing complex datasets, simulating experiments, and discovering new insights in fields such as astronomy, biology, chemistry, and environmental science.

3.1 COMPONENTS DESCRIPTION

3.1.1 LCD

The acronym LCD stands for liquid crystal display. It is a type of electronic display module that is used in a wide variety of applications, including circuits and devices such as mobile phones, calculators, computers, televisions, and so on. These displays are best suited for multi-segment light-emitting diodes with seven segments. The main advantages of adopting this module include its low cost, simplicity of programming, animations, and the lack of limits for displaying unique characters, special and even animations, and so on.

Fig 2:16X2 LCD

3.1.2 Buzzer:

Fig 3: Active Passive Buzzer

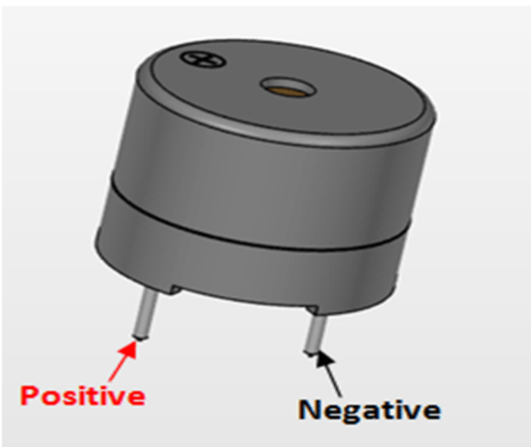


Fig 4:Active Passive Buzzer Pinout

3.1.3 DHT11 Temparature and Humidity sensor:

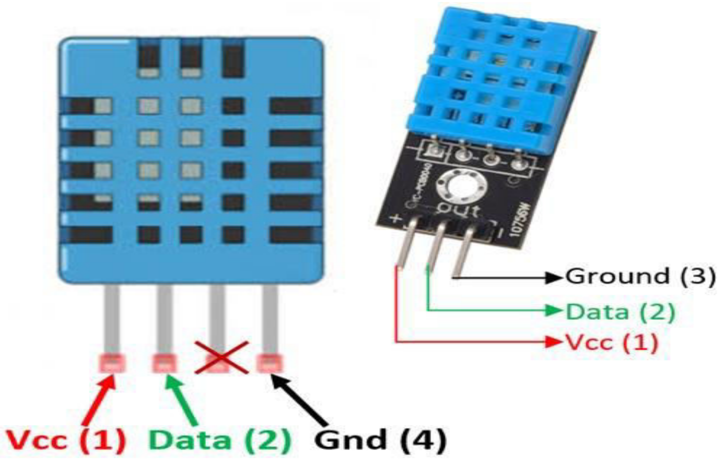


Fig 4 :DHT11 pin diagram

- The **DHT11** is a commonly used **Temperature and humidity sensor that** comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values
- of temperature and humidity as serial data.

3.1.4 GSM (Global System for Mobile communications)

GSM (Worldwide Framework for Portable correspondences) is a cell organization, and that implies that cell phones associate with it via looking for cells in the quick area. GSM networks work in four different recurrence ranges. Most GSM networks work in the 900 MHz or 1800 MHz groups. A few nations in the Americas utilize the 850 MHz and 1900 MHz groups on the grounds that the 900 and 1800 MHz recurrence groups were at that point distributed. The more extraordinary 400 and 450 MHz recurrence groups are relegated in certain nations, where these frequencies were recently utilized for original frameworks. GSM-900 purposes 890-915 MHz to send data from the versatile station to the base station (uplink) and 935-960 MHz for the other heading (downlink), giving 124 RF channels (channel numbers 1 to 124) dispersed at 200 kHz. Duplex separating of 45 MHz is utilized. In certain nations the GSM-900 band has been stretched out to cover a bigger recurrence range. This 'broadened GSM', E-GSM, utilizes 880-915 MHz (uplink) and 925-960 MHz (downlink), adding 50 channels (channel numbers 975 to 1023 and 0) to the first GSM-900 band. Time division multiplexing is utilized to permit eight full-rate or sixteen half-rate discourse channels per radio recurrence channel. There are eight radio timeslots (giving eight burst periods) gathered into what is known as a TDMA outline. Half rate diverts utilize substitute edges in the equivalent timeslot. The channel information rate is 270.833 kbit/s, and the casing length is 4.615 ms.

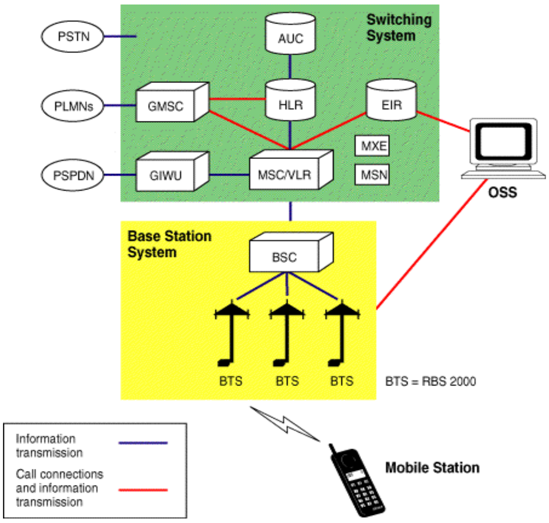


Fig 5::Switching system

3.1.5 Flame sensor

A flame sensor is a sensor that responds the most to regular light. That is why this sensor module is employed in fire alarms. This sensor detects flames at wavelengths ranging from 760 nm to 1100 nm from the light source. This sensor is readily damaged by high temperatures. As a result, this sensor can be placed a specific distance away from the flame. Flame detection may be done from a distance of 100cm, with a detection angle of 600. This sensor generates an analogue or digital signal. These sensors are utilised in firefighting robots as flame alarms.

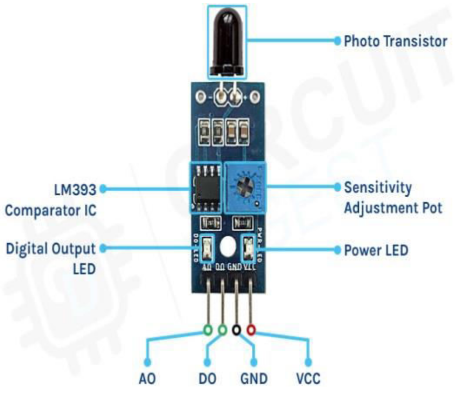


Fig 6:Flame sensor

3.1.6 Voltage Sensor

This sensor is utilized to screen, work out and decide the voltage supply. This sensor can decide the air conditioner or DC voltage level. The contribution of this sensor can be the voltage though the result is the switches, simple voltage signal, an ongoing sign, a discernible sign, and so forth. A few sensors give sine waveforms or heartbeat waveforms like result and others can create yields like AM (Plentifulness Balance), PWM (Heartbeat Width Regulation) or FM (Recurrence Tweak). The estimation of these sensors can rely upon the voltage divider. This sensor incorporates info and result. The info side chiefly incorporates two pins specifically certain and negative pins. The two pins of the gadget can be associated with the positive and negative pins of the sensor. The gadget positive and negative pins can be associated with the positive and negative pins of the sensor. The result of this sensor primarily incorporates supply voltage (Vcc), ground (GND),analog o/p data.

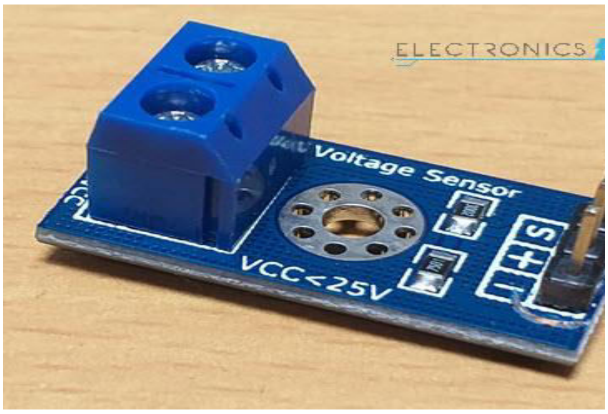
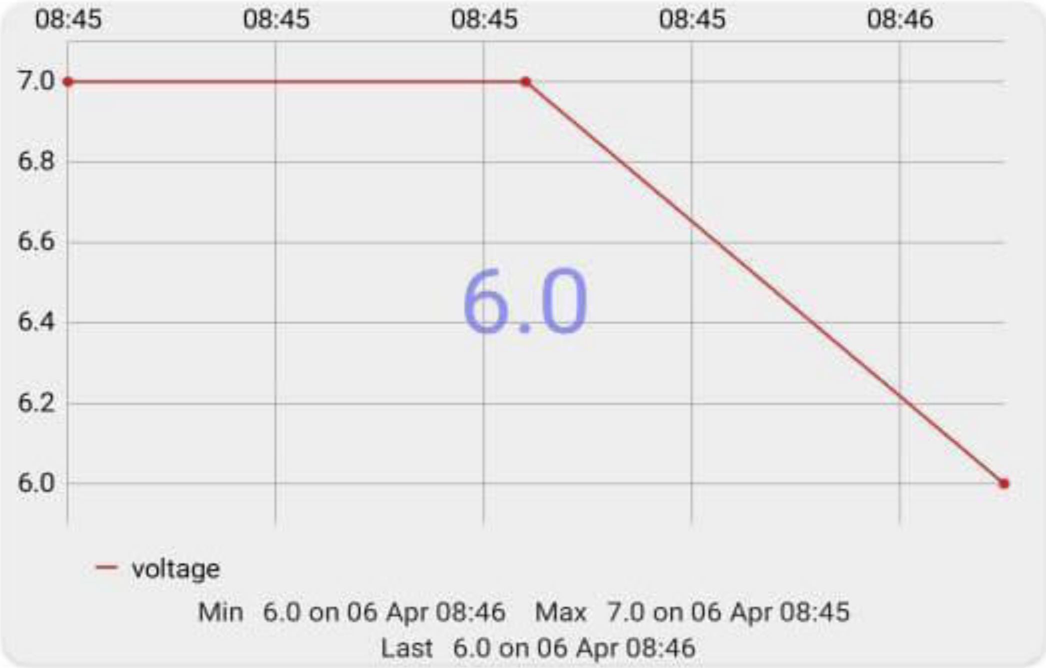


fig 7:voltage sensor

4.RESULTS AND DISCUSSION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voltage
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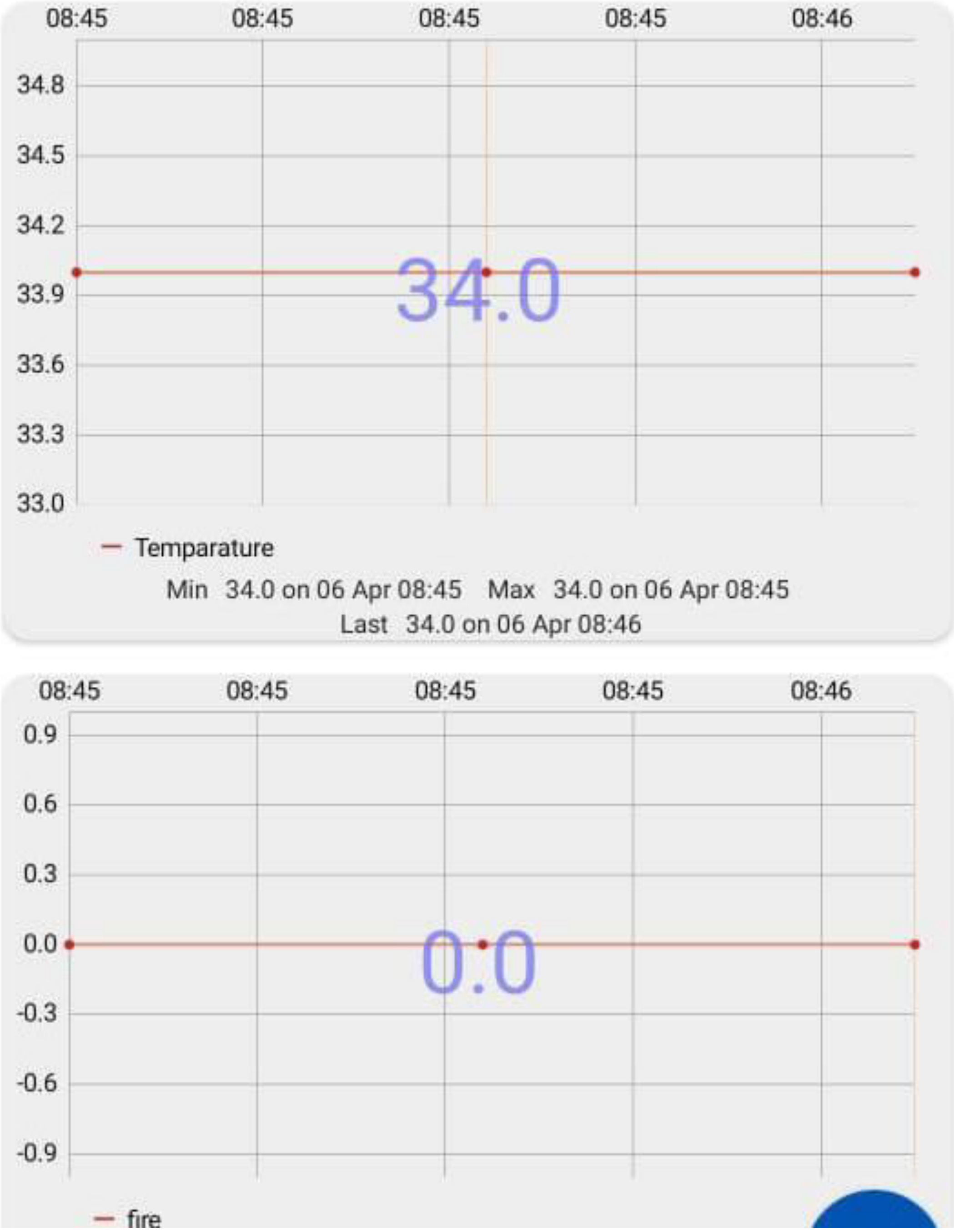
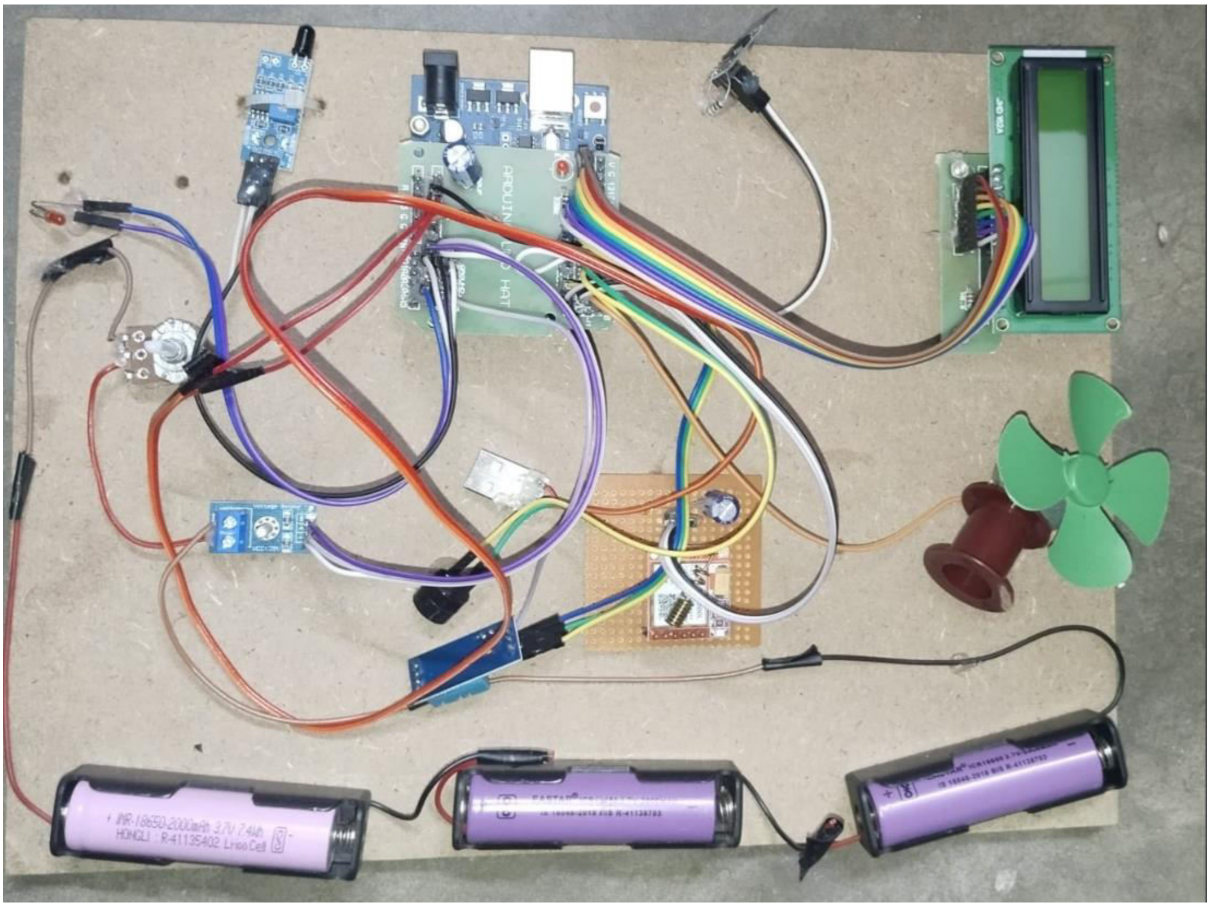
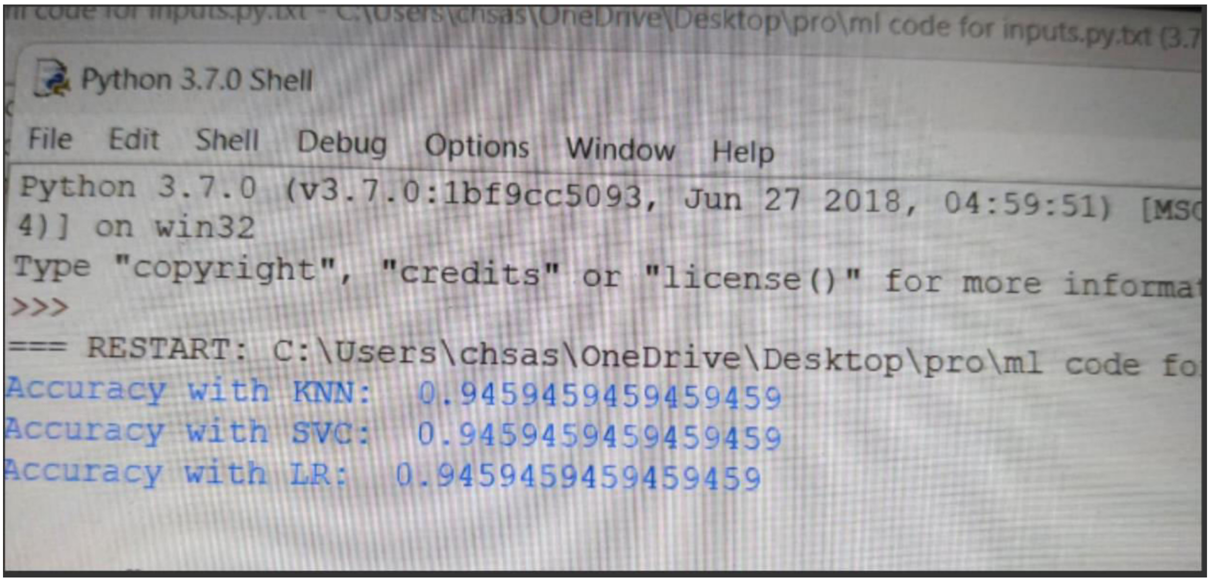


The developed battery monitoring system is also consists of a web-based user interface. The user interface is capable to monitor multiple battery

Therefore, the idea of the user interface has taken into consideration the situation where there is a need to monitor multiple batteries conditions.

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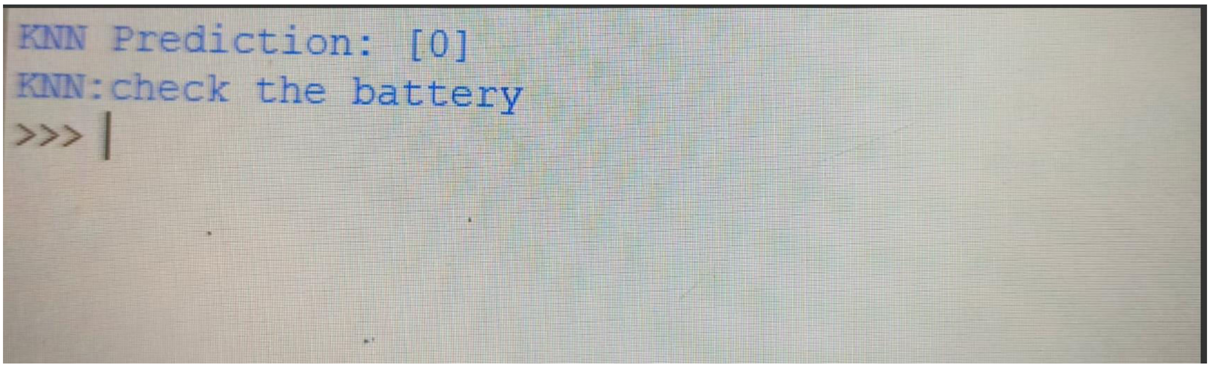
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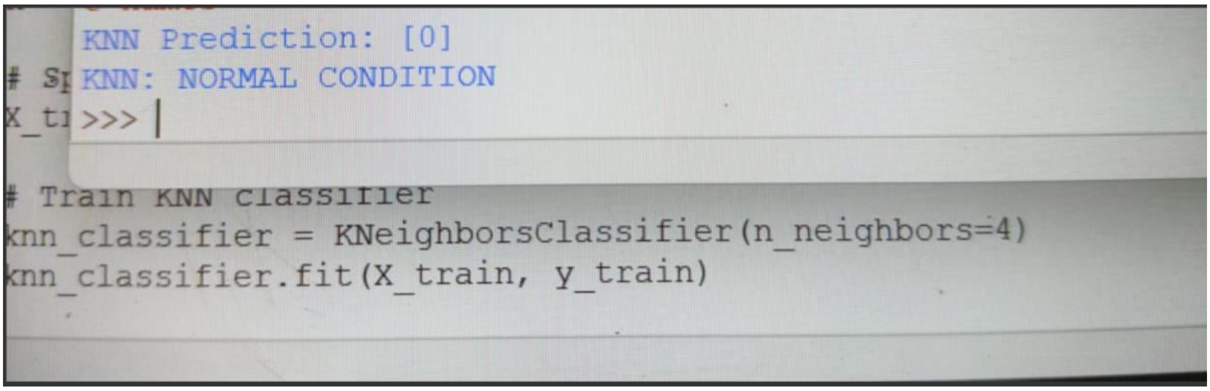

5.CONCLUSION AND FUTURE SCOPE

Finally, the EV BMS with charge monitor and fire prevention is a critical component of electric vehicles that ensures the battery pack's security, dependability, and longevity. By providing critical safety features such as temperature management, fault detection, cell balancing, and fire prevention, the system reduces the chance of battery fires while increasing the overall efficiency of electric vehicles.More research and development may be done to increase the features and capabilities of EV BMS with charge monitor and fire protection. Some potential future study topics include improving the precision and dependability of battery monitoring systems to offer more precise and timely data about the charge, health, and function of the battery pack.

5.1 The future scope includes the following:

Advanced Data Analytics: Implementing advanced data analytics techniques to analyze battery performance data collected from IoT sensors. This can include predictive maintenance algorithms to anticipate battery failures or degradation, optimizing charging and discharging strategies, and identifying trends for performance improvement.

Remote Configuration and Management: Enabling remote configuration and management of the battery monitoring system through IoT connectivity. Users can adjust settings, update firmware, and monitor system status from anywhere, enhancing convenience and accessibility.

Integration with Energy Management Systems: Integrating the battery monitoring system with broader energy management systems to optimize energy usage and storage. This integration can facilitate smart grid integration, load balancing, and demand response, contributing to energy efficiency and grid stability.

Enhanced Security Features: Implementing robust security features to protect the battery monitoring system from cyber threats and unauthorized access. This can include encryption protocols, secure authentication mechanisms, and intrusion detection systems to safeguard sensitive data and system integrity.

Multi-Platform Compatibility: Ensuring compatibility with multiple IoT platforms and communication protocols to accommodate diverse deployment scenarios and interoperability with existing infrastructure. This can include integration with popular IoT platforms such as AWS IoT, Microsoft Azure IoT, or Google Cloud IoT, as well as support for protocols like MQTT, CoAP, or HTTP.

Scalability and Modular Design: Designing the battery monitoring system with scalability and modularity in mind to accommodate future expansion and customization. This can involve using modular hardware components, scalable software architectures, and standardized interfaces to simplify integration with additional sensors or devices.

Real-Time Monitoring and Alerts: Implementing real-time monitoring capabilities to provide immediate feedback on battery status and performance. Users can receive alerts and notifications via email, SMS, or mobile apps in case of critical events such as battery overcharging, overheating, or voltage fluctuations, enabling prompt action to mitigate risks.

Energy Harvesting and Sustainability: Exploring energy harvesting techniques to power the battery monitoring system using renewable energy sources such as solar or kinetic energy. This can enhance system sustainability and reduce reliance on external power sources, especially in remote or off-grid locations.

Integration with Smart Grid Technologies: Integrating the battery monitoring system with smart grid technologies such as demand response programs, grid-connected storage, or vehicle-to-grid (V2G) systems. This integration can enable bidirectional energy flow between the battery system and the grid, supporting grid stabilization and renewable energy integration initiatives.

Community Engagement and Open Source Development: Fostering a community-driven approach to development by sharing designs, code, and documentation as open-source resources. This can encourage collaboration, innovation, and knowledge exchange among developers, researchers, and enthusiasts, driving continuous improvement and adoption of the battery monitoring system.

By exploring these future directions, the battery monitoring system using Arduino and IoT can evolve into a versatile and resilient solution for monitoring, managing, and optimizing battery performance across a wide range of applications, from renewable energy storage and electric vehicles to consumer electronics and industrial automation**.**

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