ARDUINO-BASED SMART CAR SAFETY SYSTEM

A PROJECT REPORT

Submitted by

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22010301344	22013002739 of 2022-2023	BWU/BCA/22/364	Souvik Bairi

In partial fulfillment for the award of the degree

of

BACHELOR OF COMPUTER APPLICATIONS

IN

DEPARTMENT OF COMPUTATIONAL SCIENCES

BRAINWARE UNIVERSITY

398, Ramkrishnapur Road, Barasat, North 24 Parganas, Kolkata - 700 125

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DEPARTMENT OF COMPUTATIONAL SCIENCES

BONAFIDE CERTIFICATE

Certified that this project report "**ARDUINO-BASED SMART CAR SAFETY SYSTEM**" is the bonafide work of "**Debanjan Bera, Partha Biswas, Bristi Chakraborty, Priya Bhattacharya, Soumadip Chandra, Souvik Bairi**" who carried out the project work under my supervision.

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Project Title: ARDUINO-BASED SMART CAR SAFETY SYSTEM

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Abstract

This project focuses on the development of a cost-effective, multifunctional smart car system using the Arduino Uno microcontroller, designed to enhance vehicle safety, environmental monitoring, and real-time user interaction. The system integrates several intelligent features in a sequential manner, making it ideal for both educational and prototyping purposes. First, obstacle detection is achieved through ultrasonic sensors, enabling the vehicle to identify objects in its path and automatically stop or issue timely alerts to prevent collisions. Next, the system ensures electrical safety and operational efficiency through continuous battery condition monitoring, utilizing a voltage sensor to track battery voltage levels and a current sensor to observe current flow, effectively preventing issues like overcurrent, deep discharge, and power loss. In addition to electrical monitoring, a temperature sensor is incorporated to constantly check internal heat levels, providing early warnings to prevent overheating during extended operations. Furthermore, a smoke and gas detection system, based on a smoke sensor, monitors the surrounding environment for harmful gases, triggering immediate alerts in hazardous conditions to safeguard both the system and its surroundings. For wireless control, the system integrates an HC-05 Bluetooth module, allowing users to manually operate the car through a dedicated Android application. This custom-built app serves as a centralized platform, displaying real-time sensor data including obstacle proximity, battery voltage and current status, temperature readings, and smoke detection alerts, along with providing movement control options. By leveraging the flexibility and user-friendliness of Arduino, this smart car system offers a highly interactive, scalable, and affordable solution. It demonstrates the practical application of embedded systems in modern intelligent transportation, while emphasizing proactive safety measures and promoting the integration of IoT concepts in automotive development.

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Chapter 1: Introduction

The evolution of smart vehicles has revolutionized automotive safety, performance, and user experience by integrating embedded systems, sensors, and IoT technologies. As the demand for intelligent and responsive transportation grows, advancements in automation and connectivity have become essential in enhancing both driver convenience and road safety. This project introduces an Arduino-based smart car equipped with a suite of advanced features including real-time battery health monitoring, smoke detection, obstacle avoidance, Bluetooth control, and OLED display feedback for user-friendly interactions. This system utilizes the MQ-2 smoke sensor for early fire detection, ensuring that the car halts immediately upon sensing dangerous smoke levels and promptly sends alerts to both the user and the nearest fire station. This feature aligns with the growing need for in-vehicle fire safety and proactive emergency response systems **(Lakshmi et al., 2024)**. Additionally, ultrasonic sensors are employed for accurate obstacle detection, enhancing operational safety by offering quick response mechanisms to prevent collisions in real-time **(Azeta et al., 2019; Aliyu et al., 2017)**. Furthermore, the car includes an intelligent Battery Management System (BMS) capable of predicting battery lifespan and ensuring reliable power availability—critical for electric vehicle performance and longevity (**Sheikh et al., 2020; Pradhan & Chakraborty, 2022**). A mobile application offers real-time remote monitoring of battery levels, system alerts, and obstacle detection status, thereby supporting interactive control and smart decision-making. Together, these innovations contribute toward building a connected, intelligent, and autonomous vehicle tailored for modern mobility needs, while also laying a foundation for future enhancements such as auto-parking, overspeed control, driver health monitoring, and solar power integration **(Tippannavar et al., 2022; Liang & Chen, 2021)**.

Chapter 2: Literature Review

Smart vehicle technologies have seen great advancements in the past, with the emergence of microcontrollers and sensors leading the charge in enhancing vehicle automation and safety. In recent times, smart vehicles utilize a combination of ultrasonic sensors, motor drivers, and battery health management systems to improve efficiency and avoid accidents. These achievements have made vehicles smarter, safer, and more reliable in real-world conditions.

Smart obstacle detection is a vital aspect of vehicle safety systems. Azeta et al. (2019) conducted a study on mobile robots that utilize ultrasonic sensors to detect nearby objects. Their system used sound waves to measure the distance between the robot and any obstacle by calculating the time delay in the echo. The study confirmed that ultrasonic sensors are reliable and accurate for preventing collisions in real-time, making them suitable for applications in both industrial and autonomous environments. This forms the basis for using ultrasonic sensors in our car to stop movement when an object is detected. **(Azeta et al., 2019)**

Building on similar safety mechanisms, Aliyu et al. (2017) proposed an automatic braking system based on ultrasonic sensor inputs. In their approach, the sensor detects obstacles in the vehicle’s path and immediately triggers a braking response. Their system was able to prevent collisions by measuring the distance to objects and applying automatic stopping at the right time. This approach aligns with our project’s obstacle detection mechanism, where ultrasonic sensing is used to ensure real-time reaction and halt the car when required. **(Aliyu et al., 2017)**

Battery health monitoring is essential for the performance and safety of electric vehicles. M. Senthilkumar et al. (2021) introduced an Arduino-based Battery Monitoring System (BMS) that could track critical parameters such as voltage, current, and temperature. This system was capable of sending the data to a mobile app for user-friendly access. It also helped collect real-time data that could be used in future for machine learning-based health predictions. The simplicity and effectiveness of this model greatly inspired the integration of voltage and current sensors in our smart car system for continuous monitoring and mobile-based alerts. **(M. Senthilkumar et al., 2021)**

For simple and cost-effective battery health diagnostics, Pradhan and Chakraborty described how Arduino can be used to measure battery voltage using a voltage divider circuit. This method safely reduces the battery voltage so that Arduino can read it and provide real-time output to users. They also recommended adding basic components like resistors and capacitors to improve stability. Their work showed how car owners and hobbyists can keep track of battery health using minimal components, which influenced our use of basic voltage sensing in this project. **(Pradhan & Chakraborty, 2022)**

Taking a more advanced approach to battery diagnostics, Sheikh et al. (2020) suggested a DIY method using Arduino, incorporating not only voltage sensing but also temperature and current sensors for a complete battery profile. Their method aimed to detect early warning signs of battery degradation and avoid sudden failures. They emphasized the importance of using multiple sensor types for better results, which influenced our decision to implement a comprehensive battery monitoring unit combining all three sensors. **(Sheikh et al., 2020)**

In the field of obstacle avoidance in autonomous vehicles, Large et al. (2004) explored cooperative motion prediction strategies. Their work focused on how autonomous vehicles, especially in industrial settings, can detect objects and avoid collisions through shared sensor data and simulations. This study illustrated the potential for real-time decision-making using sensor feedback. The sensor-based avoidance strategies proposed in their research inspired the practical application of ultrasonic sensors in our vehicle for safe navigation. **(Large et al., 2004)**

Battery capacity estimation plays a crucial role in managing electric vehicle performance. Rezvanizaniani et al. (2014) provided a detailed review of on-board battery capacity estimation techniques. They discussed multiple algorithms that help determine the remaining charge and energy capacity in lithium-ion batteries. Understanding battery capacity directly within the vehicle ensures safety, improves battery lifespan, and supports better decision-making during vehicle operation. Their research supports our idea of using sensor feedback to monitor and estimate battery status. **(Rezvanizaniani et al., 2014a)**

Monitoring the internal condition of batteries is key to reliability. Widodo et al. (2011) proposed an intelligent method for battery health monitoring using a concept called sample entropy. This method analyzed the complexity of voltage signals to detect signs of battery deterioration. The ability to observe voltage patterns and identify abnormalities before they cause problems offers a smart way to maintain system health. Their findings highlight the importance of early prediction of battery issues, which aligns with our project's goal of real-time monitoring. **(Widodo et al., 2011b)**

In another important study, Tian et al. (2024) presented a comprehensive review of Battery Management Systems (BMS) in electric vehicles. They discussed the growing need for efficient monitoring of parameters such as battery aging, temperature rise, and charging efficiency. They also emphasized how smart algorithms and sensor fusion can improve BMS performance. This research supported our decision to include multiple sensors in the battery module for complete health tracking and alert generation. **(Tian et al., 2024)**

Smoke detection is becoming increasingly important for in-vehicle safety. Lakshmi et al. (2024) developed an IoT-based smoke detection system that could identify dangerous gas levels inside vehicles. Their system sent alerts to users and the nearest fire station, helping avoid fire accidents. The use of sensors like MQ-2 or MQ-135 enabled quick detection of gases such as methane and LPG. This study strongly influenced our decision to use the MQ-2 sensor in the smart car to ensure safety from gas leaks and smoke buildup. **(Lakshmi et al., 2024)**

Wireless communication is essential in modern safety systems. Sposaro and Tyson (2009) designed an Android app called iFall, which sends immediate alerts during falls or emergencies. Their concept of mobile-based monitoring inspired the idea of linking a smartphone application with the Arduino-based car system. In our project, the app not only displays sensor values but also notifies users in case of temperature rise, smoke detection, or obstacles, ensuring remote awareness and safety. **(Sposaro et al., 2009)**

These studies offer valuable insights into the use of sensors, microcontrollers, and wireless communication in vehicle safety and monitoring systems. Their contributions provided the technical and conceptual foundation for designing this Arduino-based smart car system, which integrates multiple safety features to support real-time decision-making and user alerts.

Chapter 3: Theory, Methodology, Materials & Methods

3.1 Theory

Suppose you have a car that is a little car that can drive automatically and avoid any obstacles that are coming in its way. It has this very small computer that is an Arduino Uno, controlling everything. The Arduino Uno is like a brain it processes lots of data from so many sensors, then it takes its decision based on that information. Ultrasonic sensors are like the eyes of this vehicle. These sensors send out sound waves and measure how long it takes for the waves to bounce back after hitting an object. This helps the car detect obstacles in its path and avoid them. In addition, the car has sensors that monitor the health of the battery. These sensors measure the current, or how much electricity is flowing, and the voltage, or the electrical pressure, of the battery. This would monitor the readings on the sensors that the car's battery might give a poor report, causing the car not to be operational abruptly. Sensors sense an obstruction and change in battery health to communicate these to Arduino Uno. The Arduino makes a judgment from the reading processed by this and then responds to it with whatever action has been determined to carry out. For instance, if the Arduino detects that there is an obstacle ahead, it may alert the car to stop or turn. If the health of the battery is bad, the Arduino may alert the user to check on the battery. Temperature sensor monitors the heat conditions around the car and warns if overheating occurs. Smoke sensor detects harmful gases or smoke in the environment that may harm the system. Bluetooth module allows communication with external devices like smartphones. A dedicated Android application is developed to pair with the smart car system via Bluetooth. This application receives real-time data from the car and sends instant notifications and safety alerts to the user. It ensures the user is always informed about the car’s status including obstacle detection, battery health, temperature or smoke-related risks. This smart car system uses an Arduino Uno to control the car movements, monitor various sensor data and communicate to the user through the Android app, making it safer and more reliable.

3.2 Materials Used

Chassis (Including motors and wheels): The main body of the car consists of the chassis. Alongside there will be four motors for the four wheels which will lead down the car. The chassis serves as the structural framework of the car. It includes four DC motors attached to wheels, allowing the car to move forward, backward, and stop as controlled by the motor driver shield.

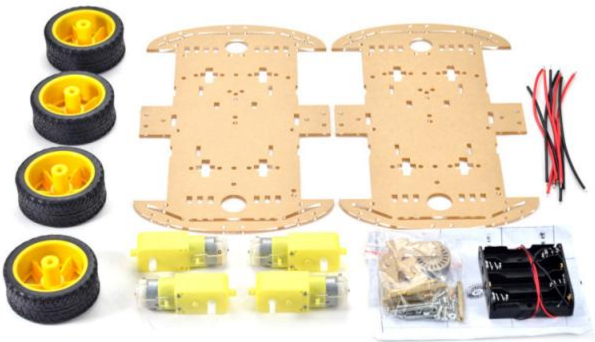

Figure 1: Car chassis

Source: ardubotics.eu/7548-thickbox/4-wheel-robot-smart-car-chassis-kits-car-for-arduino-car.jpg

Arduino Uno: Central microcontroller unit controlling all sensors and motors. The board is equipped with sets of digital and analog input/output pins that may be interfaced with various expansion boards and other circuits. It processes data from all sensors and sends control signals to the motor driver shield. Its versatility and ease of programming make it ideal for this project.

Figure 2: Arduino Uno

Source: https://cdn-reichelt.de/bilder/web/xxl_ws/A300/ARDUINO_UNO_DIP_01.png

Ultrasonic Sensor: The ultrasonic sensor detects obstacles by emitting ultrasonic waves and measuring their reflection time. It measures the distance between the car and obstacles by sending and receiving ultrasonic pulses. The data is sent to the Arduino Uno, which calculates the distance of the obstacle. If the obstacle is within a critical range, the car stops automatically.

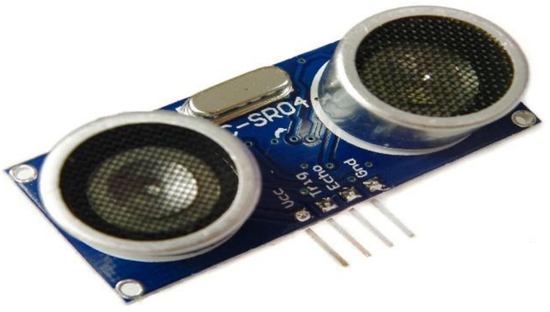

Figure 3: Ultrasonic Sensor

Source: https://cdn.shopify.com/s/files/1/0176/3274/articles/hc-sr04.jpg?v=1561459669

L293D Motor Control Shield: The L293D Motor Control Shield is a driver board that allows an Arduino to control up to four DC motors. It is responsible for controlling the DC motors of the car. With ultrasonic sensors and Arduino, it helps the car navigate by responding to detected obstacles. The shield allows forward, backward, and stop functionalities.

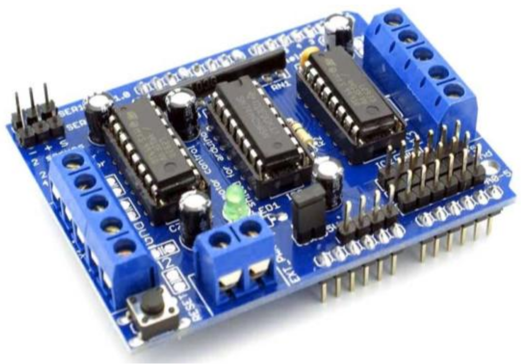

Figure 4: L293D Motor Control Shield

Source: https://www.heelectronicslk.com/wp-content/uploads/2022/11/l293d-motor-shield-1.jpg

Jumper Wires: Jumper wires are used to make electrical connections between components on a breadboard or other prototyping platforms. Jumper wires are used to create the electrical connections between the sensors, Arduino Uno, and other components. They ensure a reliable flow of current between components.

Figure 5: Jumper Wires

Source: https://armsol.in/wp-content/uploads/2022/06/Female-to-female-jumper-wire-20cm.jpeg

OLED Display: The OLED or Organic Light Emitting Diode provides real-time feedback on battery health and obstacle detection. It shows voltage levels, current readings, and system warnings, ensuring user awareness of the vehicle's status.

Figure 6: OLED Display

Source: https://docs.sunfounder.com/projects/umsk/en/latest/_images/27_OLED.png

Current Sensor: The current sensor monitors the flow of electric current from the battery to the components. It ensures safety by detecting abnormal current flow, which could indicate issues like short circuits or overloading. It monitors the battery current flow.

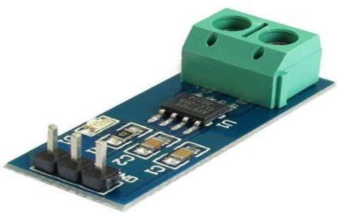

Figure 7: Current Sensor

Source: https://www.deltakit.net/wp-content/uploads/2017/06/Current-Sensor.jpg

Voltage Sensor Module: The voltage sensor continuously monitors the battery's voltage level. If the voltage drops below a critical limit, the system displays an alert on the LCD screen, preventing battery damage or system failure. It measures battery voltage.

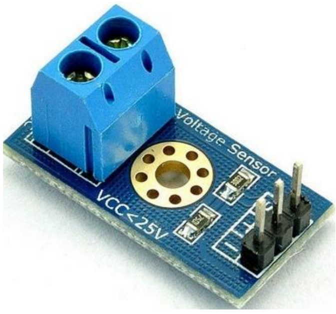

Figure 8: Voltage Sensor

Source: ifuturetech.org/wp-content/uploads/2020/04/Voltage-Detection-Sensor-Module-25V.jpg

Temperature Sensor: The temperature sensor monitors the surrounding temperature near the electronic components. If the temperature rises beyond safe operating limits, it sends signals to the Arduino which then informs the user by displaying an alert. This helps prevent internal damage and overheating.

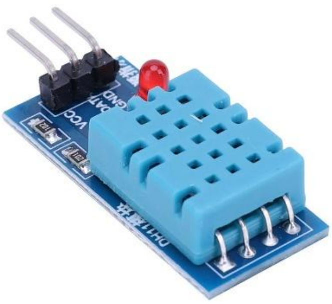

Figure 9: Temperature Sensor

Source: https://probots.co.in/dht11-humidity-and-temperature-sensor-module-for-arduino.html

Rechargeable Battery Pack: The rechargeable battery pack powers the entire system. It provides the necessary voltage and current for the sensors, motors, and Arduino board to function efficiently.

Figure 10: Rechargeable Battery Pack

Source: https://asset.conrad.com/media10/isa/160267/c1/-/en/1410110_BB_01_FB/image.jpg

Smoke Sensor: The smoke sensor detects the presence of smoke or any harmful gas around the car. It plays a vital role in identifying any potential fire or hazardous conditions. Once detected, the data is passed to the Arduino which triggers a user warning immediately.

Figure 11: Smoke Sensor

Source: cdn.shopify.com/s/files/1/0300/6424/6919/products/MQ2-Gas-Sensor-Module_1200x1200.jpg?v=1645426240

Bluetooth Module: The Bluetooth module allows the smart car to connect wirelessly with a smartphone or computer. It sends real-time data such as obstacle alerts, battery health, temperature and smoke alerts to the user, helping in easy monitoring and control of the system.

Figure 12: Bluetooth Module

Source: https://wonderfulengineering.com/wp-content/uploads/2018/07/Best-Bluetooth-Modules-For-Arduino-4.jpg

3.3 System Design & Architecture

The proposed Arduino-based smart car safety system integrates three core safety modules: obstacle detection, battery health monitoring, and smoke detection. These modules work together through a centralized microcontroller to ensure continuous vehicle safety monitoring and timely hazard alerts. The system follows a modular architecture composed of three functional layers: sensor input, data processing, and response actuation.

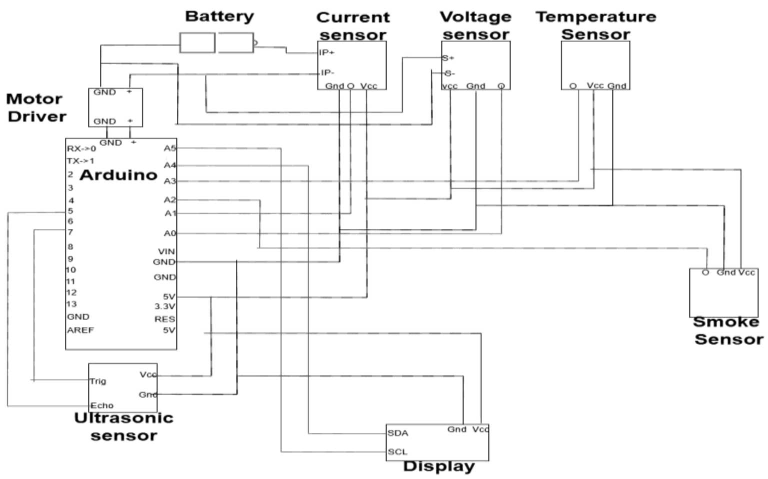

Figure 13: Circuit Diagram

Source: Self created

At the heart of the system is the Arduino Uno, selected for its simplicity, real-time processing capabilities, affordability, and widespread compatibility with sensor modules. Compared to alternatives like the Raspberry Pi or ESP32, the Arduino Uno provides a low-power, hardware-oriented solution ideal for embedded automotive safety systems. The detailed technical specifications of the Arduino Uno are as follows:

The system employs various sensors to detect different safety parameters. A summary of the technical specifications of these modules is provided below. A visual representation of the full circuit layout shows how the sensors, microcontroller, motor driver, and output modules are interconnected.

Table 1: Arduino Uno – Technical Specifications

Parameter	Specification
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7–12V
Digital I/O Pins	14(6PWM-enabled)
Analog Input Pins	6
Clock Speed	16MHz
Flash Memory	32KB (0.5KBused bootloader)
SRAM	2KB
EEPROM	1KB
Communication Interfaces	UAR, SPI, I2C

Table 2: Sensors Used in the Smart Car System

Sensor Type (model)	**Parameter Range**
Ultrasonic Sensor (HC-SR04)	Distance: 2–400 cm, ±3mm
Voltage Sensor (Generic)	Voltage:0–25V, ±0.1V
Current Sensor (ACS712(5A))	Current: ±5A, ±1.5%
Temperature Sensor (DHT11)	Temp:0–50°C, ±2°C
Smoke Sensor (MQ2)	Smoke/Gas: 300–10,000ppm, 2–5s

The Smart Car Safety System uses an HC-SR04 ultrasonic sensor to detect obstacles within 2 cm to 20 m by measuring the time it takes for sound waves to bounce back. If an object is too close, the system stops the motor and activates visual and audible alerts. Battery health is monitored using a voltage sensor, an ACS712 current sensor, and a DHT11 temperature sensor. These sensors send data to the Arduino Uno, which checks for unsafe conditions and displays real-time metrics on an OLED screen. The MQ2 gas sensor is used for smoke detection, identifying gases like methane, CO, and LPG. If gas levels exceed 300 ppm, the system triggers alerts through buzzers, and the shared OLED. All sensors are connected to the Arduino Uno, which controls the DC motors via the L293D motor driver. This setup ensures real-time hazard detection and alerts, making the system suitable for both traditional and autonomous vehicles.

3.4 Methodology and Methods

The heart of the Arduino-based smart car system lies in the seamless collaboration of multiple sensors and components all working together to achieve obstacle detection motor control and battery health monitoring. Each part has a specific role in the system contributing to the car's smooth operation and safety features. At the core of the system is the Arduino Uno Microcontroller which serves as the brain of the entire setup. It processes data collected from the ultrasonic sensor current sensor voltage sensor temperature sensor smoke sensor and the Bluetooth module interpreting this information in real-time. Based on the data received the microcontroller decides how the vehicle should respond. For example, if the ultrasonic sensor detects an object too close the Arduino immediately commands the motor driver to halt the motors preventing a collision. Similarly, if the battery’s current or voltage levels exceed safe limits the Arduino sends an alert to the display screen ensuring the operator can take necessary actions.

The ultrasonic sensor is a key component responsible for obstacle detection. This sensor works by emitting high-frequency sound waves that travel through the air. When these waves strike an object, they bounce back to the sensor which measures the time taken for the echo to return. Using this data the Arduino calculates the distance between the car and the obstacle. If an object is detected within a critical range the microcontroller takes immediate action to stop the car enhancing safety.

To manage motor control the L293D motor driver shield plays a crucial role. It acts as the intermediary between the Arduino Uno and the DC motors receiving movement commands from the microcontroller. Whether the vehicle needs to move forward reverse or come to a complete stop the motor driver shield interprets signals from the Arduino and adjusts the motors accordingly. This is particularly useful during obstacle detection scenarios as the motor driver can instantly stop the motors if a potential collision is detected.

For monitoring battery health, the system includes a current sensor, a voltage sensor module and a temperature sensor. The current sensor continuously measures the electrical current flowing through the battery and circuits ensuring that it stays within a safe operational range. Meanwhile the voltage sensor keeps track of the battery's voltage levels preventing situations where the battery could drain excessively or overheat. If either the current exceeds safe limits or the voltage drops too low the Arduino processes this data and generates a warning alert on the OLED display allowing the user to take corrective measures. A temperature sensor is used to monitor the system’s thermal condition. If the temperature exceeds safe limits the Arduino receives this data and displays a high temperature warning on the OLED display preventing damage to internal components. A smoke sensor is used to detect the presence of smoke in the car to prevent potential fire hazards. If the smoke level exceeds a safe threshold, the Arduino immediately stops the car, sends an alert to the user to ensure quick emergency response to enhance safety.

The Bluetooth module is used for real-time wireless communication with a smartphone or other device. It sends sensor data including obstacle alerts battery voltage current levels temperature and smoke warnings directly to the user’s mobile device. A dedicated Android application has been developed that connects to the smart car system via Bluetooth. It receives data from the sensors and instantly sends notifications and safety alerts to the user about battery problems obstacles overheating or smoke detection ensuring the user is always informed even from a distance.

The OLED display provides real-time feedback to the user showing battery health temperature readings obstacle proximity and safety alerts. This continuous visual feedback ensures the user stays informed throughout the car’s operation. Jumper wires serve as the essential links between the various components ensuring secure and effective electrical connections. These wires connect the sensors Arduino Uno motor driver and display allowing the entire system to work as a cohesive unit.

The car's physical structure consists of a chassis with motors and wheels which supports the entire assembly. The four wheels are powered by individual DC motors giving the vehicle mobility. The motor driver shield controls the speed and direction of these motors enabling forward and backward movement as well as stopping the car when required. Powering the entire system is a rechargeable battery pack which supplies the necessary voltage and current to all components including the Arduino Uno sensors motor driver shield and motors. The battery pack ensures uninterrupted operation with the voltage and current sensors working to prevent any power-related issues.

Chapter 4: Results, Analysis and Discussions

The Arduino-based smart car system was subjected to rigorous testing to ensure the effectiveness of both obstacle detection and battery health monitoring features. Each component and functionality were evaluated thoroughly to ensure smooth and efficient operation of the vehicle under various conditions.

The obstacle detection capability was tested using the ultrasonic sensor (HC-SR04), which played a pivotal role in preventing collisions. Throughout the testing process, the sensor emitted sound waves consistently, which travelled through the air and reflected back upon hitting an object. By measuring the time taken for the waves to return, the Arduino Uno calculated the distance to the obstacle. When the object was within a predefined range of 10 cm, the system immediately halted the car. The HC-SR04 sensor supports a distance range of 2 to 20 cm with an accuracy of ±3 mm, and it demonstrated high accuracy in identifying obstacles at various distances and angles. During multiple test runs, the vehicle consistently stopped in time to avoid a collision. The reaction time of the system was fast enough to prevent any delay, ensuring the car could operate safely even in complex environments. To further validate the sensor's performance, objects of varying materials and sizes were tested. Regardless of whether the obstacle was a solid surface or a smaller object, the ultrasonic sensor was able to detect it accurately and stop the vehicle without delay. This level of responsiveness and reliability makes the system suitable for real-world applications where autonomous navigation and collision prevention are crucial.

The battery health monitoring system was another crucial element tested extensively in the smart car model. The system incorporated both a current sensor (ACS712 - 5A) and a voltage sensor (generic type), both responsible for continuously tracking the electrical state of the battery. These sensors were connected directly to the Arduino Uno, ensuring real-time data processing and monitoring. The voltage sensor measured within a 0 to 25 V range with ±0.1 V accuracy, while the current sensor supported readings up to ±5 A with ±1.5% accuracy. During the tests, the sensors accurately measured the battery's voltage levels and current flow under various conditions. If the voltage dropped below a predefined safety threshold, the system triggered a warning message on the OLED display, informing the user about the low battery condition. Similarly, if the current exceeded the defined safe limit, the system activated a visual warning, emphasizing the importance of immediate corrective action. This dual-layer protection provided an added safety net for battery management, as it effectively prevented issues such as battery over-discharge and overheating. Not only does this safeguard the longevity of the battery, but it also ensures the continued reliable operation of the smart car. By monitoring both voltage and current simultaneously, the battery management system serves as a comprehensive health monitoring tool, significantly reducing the risk of unexpected failures. This feature makes the system highly suitable for educational demonstrations where safety and reliability are essential.

The integration of both obstacle detection and battery health management was tested to evaluate the system's ability to handle multiple data inputs simultaneously without performance degradation. The Arduino Uno microcontroller was central to this process, receiving real-time data from the ultrasonic sensor, current sensor, and voltage sensor concurrently. The system effectively processed data from all sensors and responded accordingly. When an obstacle was detected, the ultrasonic sensor data prompted the motor driver to halt the vehicle instantly. Simultaneously, the battery health monitoring system continued to check voltage and current levels, and any deviation from safe operating conditions was clearly displayed on the LCD screen. The alerts were designed to be user-friendly, with easily readable messages on the display. Warnings ensured the user always remained informed about the system's operational status. Additionally, the combination of these safety features made the system highly reliable, preventing both physical collisions and electrical failures during operation. The real-time alert system proved effective during stress testing, where multiple obstacles were introduced, and varying load conditions were applied to the battery. The Arduino's ability to handle simultaneous inputs without lag or performance drop was a testament to the efficiency of the design.

The temperature sensor (DHT11) was also tested to monitor system heat levels. It was found to work efficiently in the range of 0 to 50°C with an accuracy of ±2°C. When internal temperatures exceeded safe limits, alerts were triggered to prevent overheating, especially near sensitive components like the battery and Arduino board. The MQ-2 smoke sensor effectively detected the presence of smoke within its sensitivity range of 300 to 10,000 ppm, with a quick response time of 2–5 seconds. During testing, when smoke was introduced near the sensor, the system immediately halted the smart car and sent alerts the user. This validates the sensor's critical role in fire prevention by enabling rapid response and ensuring safety in real-time scenarios. The HC-05 Bluetooth module provided seamless wireless communication between the user and the intelligent car through a mobile application. Users could remotely control the movement (forward, reverse, left, right) of the car with minimal latency. The range of Bluetooth was effective within a 10-meter radius, offering sufficient operational distance in indoor and small-scale outdoor environments. This wireless functionality demonstrates how affordable modules can bring sophisticated features like remote operation and live status updates into embedded systems.

Figure 14: Result -1

Source: Self created

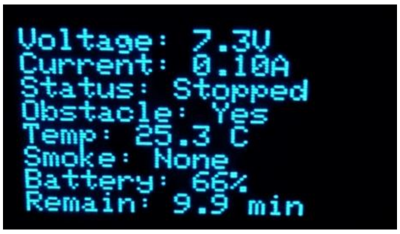

Figure 15: Result -2

Source: Self created

Figure 16: Result -3

Source: Self created

Chapter 5: Limitations, Future Scope and Conclusion

5.1 Limitations

While the project demonstrated several strengths, it also faced certain limitations. The current obstacle detection system is limited to short distances due to the range limitations of the ultrasonic sensor. To enhance its effectiveness, sensors with longer detection ranges could be considered in future iterations. The battery monitoring system, although efficient, covers only basic voltage and current measurements. It does not provide detailed battery health analytics. Incorporating advanced battery management systems that offer comprehensive health diagnostics would be a valuable improvement. The model is primarily designed for educational purposes. While it is an excellent tool for learning and experimentation, modifications would be necessary for it to be used in real-world applications. Addressing factors such as durability, scalability, and user interface would be essential steps towards making it a viable product for practical use.

Even with the enhanced performance of the system, some limitations still exist. The MQ-2 smoke detector has a short detection range and can be affected by environmental conditions such as humidity or alcohol fumes to generate false alarms. The Bluetooth control using the HC-05 module is limited to short-distance use (about 10 meters), restricting remote control to immediate surroundings. Moreover, although the system detects smoke, it does not trigger any automatic safety action such as braking or steering the vehicle. The installation also relies on a mobile application, which is likely to experience compatibility problems with various devices. Lastly, the incorporation of extra modules slightly elevates total power usage, degrading battery performance upon prolonged use.

5.2 Future Scope

Looking ahead, the smart car system can be significantly enhanced to expand its safety, efficiency, and user convenience. Future improvements include engine temperature control to prevent overheating, and the integration of automatic braking and lane-keeping assist to reduce collision risks and improve driving stability. Addressing urban traffic issues, illegal parking detection can help optimize road space usage. Incorporating solar panels will promote sustainable energy use by powering auxiliary systems. Overspeed prevention features can ensure the vehicle adheres to speed limits, especially in sensitive zones like school or hospital areas. Driver health monitoring through sensors can assess fatigue or medical conditions, ensuring the driver's fitness to operate the vehicle. Auto parking capabilities will allow the car to identify and park in available spaces automatically. A smart voice assistant can improve user interaction by offering voice-based navigation, status updates, and alerts. Additionally, a smart shading system can enhance passenger comfort by adjusting window tints based on sunlight intensity. These advancements will make the smart car more intelligent, safer, and user-friendly, aligning with the future of autonomous and connected mobility.

5.3 Conclusion

In the world of automation and smart technologies, simplicity often meets efficacy. The Arduino-based smart car system developed through this project is a testament to that. The primary goal was to showcase an efficient integration of obstacle detection and battery health monitoring, and the results were promising. One of the major component of this smart car system is the ultrasonic sensor, designed for obstacle detection. This sensor played a crucial role in preventing collisions. Whenever an obstacle was detected within a range of 10 cm, the sensor sent signals to the Arduino Uno microcontroller, which then processed the data and commanded the car to stop. This seamless interaction highlighted the potential of using microcontrollers for real-time decision-making in automation. The car's ability to avoid obstacles efficiently demonstrated the practical applicability of the system. Parallel to the obstacle detection mechanism, the battery health management system was another highlight. By utilizing current and voltage sensors, this system provided real-time monitoring of the battery's health. When the sensors detected unsafe conditions, alerts were triggered promptly. This feature not only ensured the safety of the system but also underscored the importance of continuous monitoring in maintaining the longevity and reliability of automated systems. The Arduino Uno microcontroller served as the brain of the operation, efficiently processing data and executing control commands for all the components. Its ability to handle multiple tasks simultaneously without lag proved its effectiveness. This project thus showcased the feasibility of microcontroller-based smart car models in the realm of automation and safety systems. The use of accessible and scalable components made the project attainable for enthusiasts and beginners alike. The system's reliability, ease of construction, and educational value made it an excellent platform for learning the basics of automation, sensor integration, and microcontroller programming. However, the potential of this model doesn't end here. With further enhancements, the system can evolve into a more advanced smart vehicle, suitable for real-world applications beyond educational purposes. The advanced Arduino-based smart car system is able to seamlessly integrate obstacle sensing, battery status monitoring, smoke sensing, and Bluetooth-based remote control. Adding the MQ-2 sensor provides a useful safety feature by allowing the system to sense the presence of smoke, while the HC-05 Bluetooth module enables wireless operation using an easy-to-use mobile app. These features enhance the system's usability for actual safety applications and educational purposes considerably. While there are limitations—range limitations, power drain, and absence of automated responses in emergencies—the project sets a good platform for further research into autonomous vehicle systems. In general, the intelligent car illustrates how inexpensive hardware and microcontroller programming can be merged to construct efficient, multipurpose, and interactive automation systems.

Appendix

The following images showcase the fully assembled Arduino-based smart car system, highlighting key components, their placement, and the overall structural design. These visuals provide a comprehensive understanding of the system's layout and functionality.

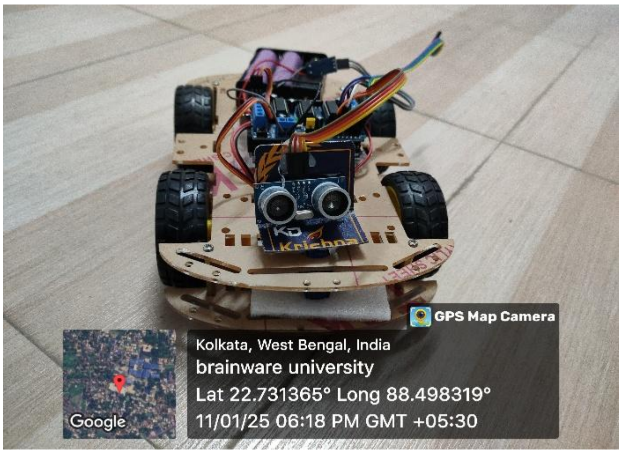

Figure 17: Car model -1

Source: Self created

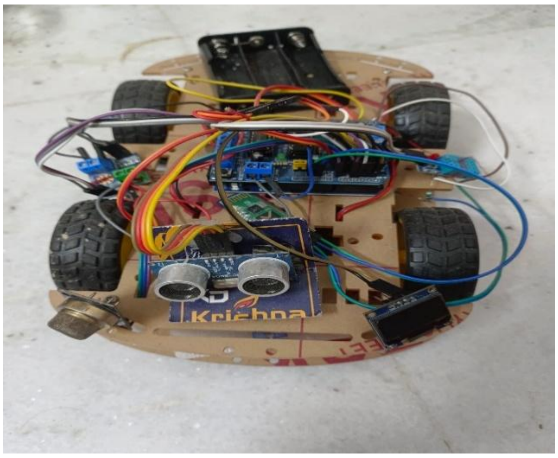

Figure 18: Car model -2

Source: Self created

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