

Automobile Black Box System for Accident Analysis

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Abstract - This paper proposes an Automobile Black Box system that records vehicle data to analyze accidents, prevent tampering, and send SMS alerts during emergencies using GSM and MEMS sensors. It also integrates RFID technology to automatically control vehicle speed in critical zones and reduce traffic violations. Additionally, ultrasonic sensors with an Arduino microcontroller enable obstacle detection and avoidance for safer driving..

IndexTerms - Automobile Black Box, Accident Detection, RFID Technology, Speed Control, GSM Communication, MEMS Sensor, Ultrasonic Sensor, Obstacle Avoidance, Raspberry pi pico, Traffic Safety

I. INTRODUCTION

Road accidents remain a critical global challenge, with over one million fatalities reported annually by the World Health Organization (WHO). In India, approximately 150,000 deaths occur each year due to road accidents, emphasizing the need for effective safety and monitoring systems. To mitigate this issue, the concept of an Automobile Black Box system has been introduced, inspired by aviation black boxes used for accident investigation. These systems are designed to record crucial vehicle data such as speed, engine parameters, and driver behavior before and during an accident. Conventional systems like Event Data Recorders (EDRs) and Accident Data Recorders (ADRs) provide limited insights, making it difficult to determine the exact cause of accidents. Therefore, an enhanced system integrating multiple sensors and real-time monitoring is proposed to improve accuracy in accident analysis. The proposed system not only records data but also transmits emergency alerts with GPS location to emergency medical services, nearby hospitals, and family members. This ensures rapid response and timely medical assistance, potentially reducing fatalities. Furthermore, the system incorporates data encryption techniques to secure stored information and prevent unauthorized access. It also enables proactive vehicle monitoring by detecting issues such as overspeeding and engine faults, contributing to preventive maintenance. In conclusion, the Automobile Black Box system enhances accident investigation, supports insurance claim processes, and improves overall road safety by enabling faster emergency response and better vehicle monitoring.

II. LITERATURE SURVEY

Many researchers have developed systems to improve road safety and accident detection. A smartphone-based method is used to detect potholes and speed breakers using vibration data from the accelerometer. This method is low-cost and easy to use compared to traditional systems. Another system uses sensors and IoT to reduce accidents by monitoring driver behavior. It includes sensors like LIDAR, alcohol detectors, cameras, and drowsiness detection. The system also uses GPS and GSM to track vehicle location and send data to servers. Some research focuses on smart road systems that detect accidents and alert nearby drivers. These systems are useful during bad weather conditions like rain or fog. They use sensors and wireless communication only when an accident occurs. IoT-based vehicle black box systems collect data such as temperature, location, and vehicle status. They send alerts during accidents and store data in cloud platforms for analysis. Emergency response systems are improved using IoT and GPS tracking. These systems help ambulances find the fastest route and reduce delays in traffic. MQTT protocol is used for fast and efficient communication between devices. It helps low-power devices send data using less internet. Sensor testing systems using Raspberry Pi ensure sensors are working correctly. They test and store sensor performance data for future use. Tracking systems using GPS, GSM, and motion sensors help in anti-theft applications. They allow users to track stolen devices and receive alerts in real time.

III. METHODOLOGY

3.1. EXISTING SYSTEM:

An Event Data Recorder or EDR is a function or device installed in a vehicle that records technical vehicle and occupant information for a brief period of time (seconds, not minutes) before, during and after a collision, for the purpose of monitoring and assessing vehicle safety system performance. EDRs have come about because less physical evidence is being left at collision scenes as vehicles are more commonly fitted with ABS (anti-lock braking system) and ESP (electronic stability program) etc. This

lack of physical evidence makes it harder to reconstruct accidents. Driver or device errors are also difficult to detect without EDRs.



DISADVANTAGES:

The Automobile Black Box exists partially in the form of Event Data Recorders (EDRs) and black boxes .It is difficult to establish the exact cause of an accident from these systems .To overcome this shortcoming, an Automobile Black Box system that combines both of these aspects is proposed.

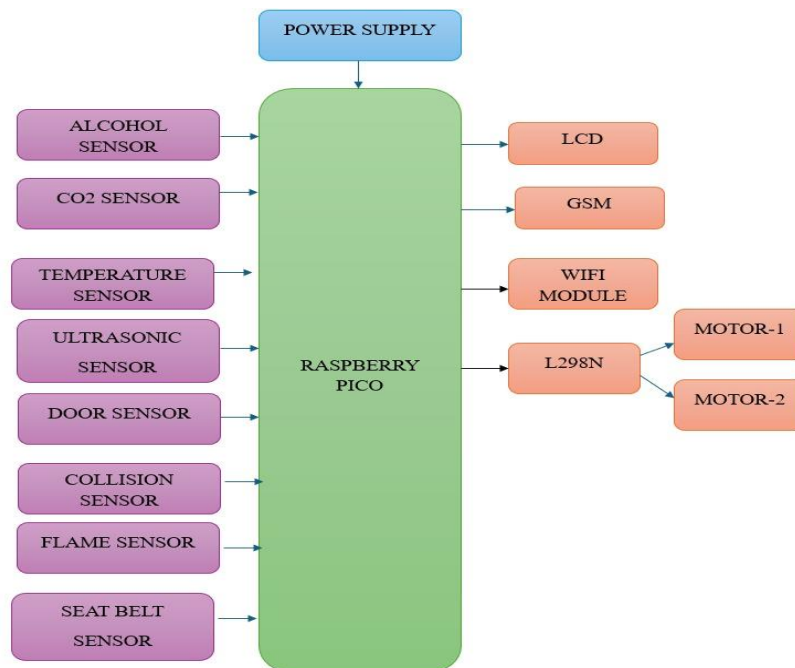
3.2. PROPOSED SYSTEM:

This paper proposes a prototype of an automatic Black Box system that can be installed into vehicles. The system aims to achieve accident analysis by objectively tracking the vehicle. The system also involves enhancement of security by preventing tampering of the Black Box data [1]. The message will be send to the pre-stored number in the case of detection of an accident. This system consists of Alcohol sensor, door sensor, Ultrasonic sensor, collision sensor, co2 sensor and temperature sensor and GSM modem. Whenever an abnormal value is detected it will send ansms to the prestored number.

Advantages:

1. Provides accurate accident analysis.
2. Sends immediate alerts using GSM.
3. Improves vehicle safety with sensors.
4. Prevents data tampering.
5. Helps emergency response and insurance claims.

3.3.BLOCK DIAGRAM:



3.4 HARDWARE REQUIREMENTS:

- RASPBERRY PI PICO

- ALCOHOL SENSOR
- DOOR SENSOR
- TEMPERATURE SENSOR
- COLLISION SENSOR
- CO2 SENSOR
- ULTRASONIC SNEOSOR
- L293 DRIVER CIRCUIT
- GSM MODEM
- DC MOTORS
- LCD

1. Raspberry Pi Pico-It is the main controller of the system. It reads data from sensors, processes it, and controls other components like GSM module, motors, and display.

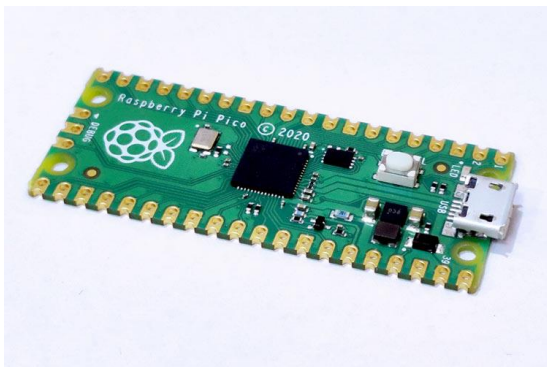
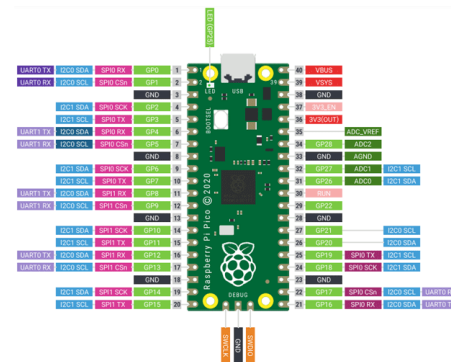


Fig : a)Raspberry Pi Pico



b) Raspberry Pi Pico Pinout

2. Alcohol Sensor (MQ3)-This sensor detects alcohol level in the driver's breath. If alcohol is detected beyond a limit, it helps in preventing unsafe driving.



3. Door Sensor-It detects whether the vehicle door is open or closed. It improves safety by monitoring unauthorized access or improper door closing.

4. Temperature Sensor-It measures the temperature inside the vehicle or engine. If temperature rises abnormally, it can alert the system.

5. Collision Sensor-This sensor detects sudden impact or accidents. When a collision occurs, it triggers an alert message.

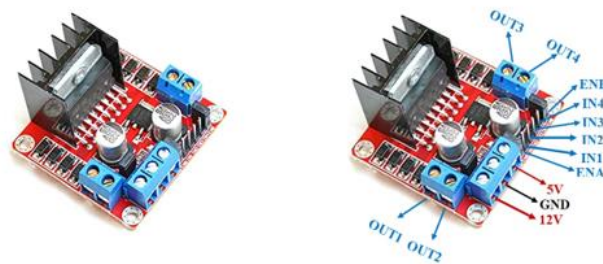
6. CO₂ (Gas) Sensor (MQ2)-It detects harmful gases like smoke, LPG, or carbon monoxide inside the vehicle to ensure safety.

7. Ultrasonic Sensor-It detects obstacles by sending ultrasonic waves and receiving echoes. It helps in avoiding collisions by measuring distance.



Figure 1: HC SR04 ultrasonic sensor. (Source: Digkey)

8. L293 Motor Driver Circuit-It controls the direction and speed of DC motors. It acts as an interface between the microcontroller and motors.

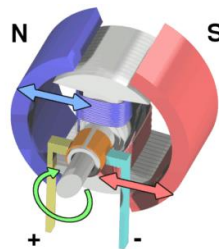


9. GSM Modem (SIM900)-It is used for communication. It sends SMS alerts to pre-stored mobile numbers during accidents or emergencies.



GSM Modem

10. DC Motors-These are used for movement or control mechanisms in the system (like obstacle avoidance vehicle).



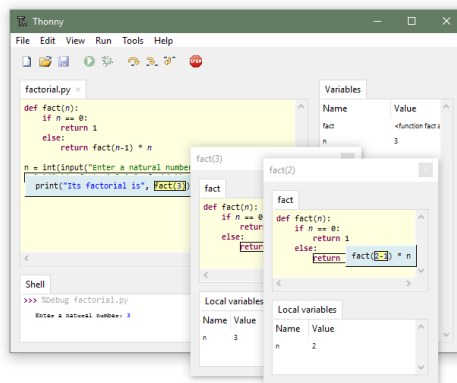
11. LCD Display-It displays important information like sensor readings, alerts, and system status.

12. Buzzer-It gives sound alerts when an abnormal condition or accident is detected.

3.5 SOFTWARE REQUIREMENTS:

- THONNY PYTHON IDE
- LINUX

1. Thonny Python IDE-It is a programming software used to write and run Python code. It is simple and beginner-friendly, especially for Raspberry Pi Pico.

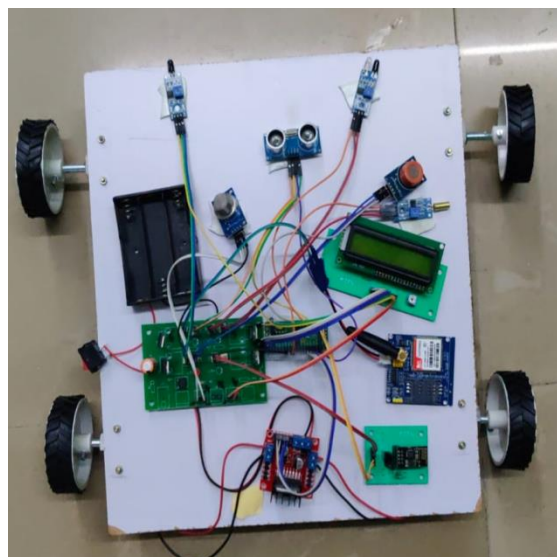


2. MicroPython-It is a lightweight version of Python used to program microcontrollers like Raspberry Pi Pico.

3. Linux Operating System-It provides the environment to run the software tools and communicate with hardware devices. It supports development and execution of programs.

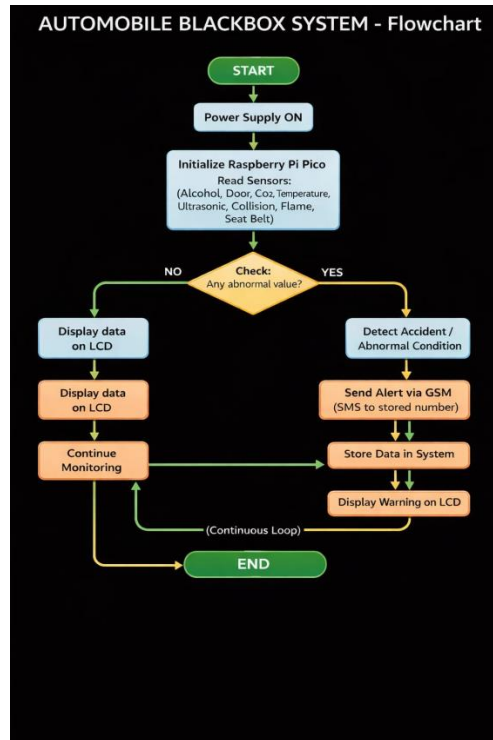
3.6 PROJECTED IMAGE:

This block diagram represents an automatic vehicle monitoring system based on the Raspberry Pi Pico microcontroller. The system uses various sensors to monitor the vehicle's condition and environment, processes the data, and communicates alerts or controls external devices accordingly.



The figure illustrates the hardware prototype of an IoT-based Car Black Box system developed using a Raspberry Pi Pico microcontroller. The entire setup is mounted on a flat base platform equipped with four wheels, representing a mobile vehicle model. At the center of the system, the control unit (Pico) is interfaced with a motor driver module that controls the movement of the wheels. Various sensors are strategically placed on the platform to enable environmental monitoring and obstacle detection. An ultrasonic sensor positioned at the front is used for distance measurement and obstacle avoidance, while IR sensors are mounted to detect nearby objects. A smoke/gas sensor is integrated to monitor air quality and detect hazardous gases, and a fire sensor is included to identify the presence of flames. Additionally, a 16x2 LCD display is connected via an I2C interface to provide real-time system information and alerts. The system is powered through a battery holder, ensuring portability. A communication module is also incorporated to enable IoT-based data transmission. The wiring connections between components demonstrate the integration of sensors, display, and motor control with the microcontroller. Overall, this prototype represents a compact and efficient embedded system capable of real-time monitoring, hazard detection, and automated vehicle control, making it suitable for smart safety and surveillance applications.

3.7 FLOW CHART



IV. RESULTS&DISCUSOIN

```

23 def stop():
24     IN1.low(); IN2.low()
25     IN3.low(); IN4.low()
26
27 def forward():
28     IN1.high(); IN2.low()
29     IN3.high(); IN4.low()
30
31 def backward():
32     IN1.low(); IN2.high()
33     IN3.low(); IN4.high()
34
35 def right():
36     IN1.high(); IN2.low()
37     IN3.low(); IN4.high()
38
39 # ----- STARTUP MESSAGE -----
40 lcd.clear()
41 lcd.putstr("CAR BLACK BOX")
42 lcd.move_to(0,1)
43 lcd.putstr("SYSTEM USING IOT")
44 sleep(3)
45
46 # ----- MAIN LOOP -----
47 while True:
48     smoke_val = smoke.read_u16()
49     fire_val = fire.value()
50     ir_val = ir.value()
51
52     lcd.clear()
53
54     # ----- DISPLAY TITLE (SHORT) -----
55     lcd.putstr("BLACK BOX SYS")
56
57     # ----- SENSOR LOGIC -----
58     if fire_val == 0:
59         <trunc>
    
```

The project implements an IoT-based “Car Black Box” system using a Raspberry Pi Pico microcontroller programmed in MicroPython through the Thonny IDE. An I2C-based LCD display is interfaced via GPIO pins (SDA–GPIO0 and SCL–GPIO1) to present system messages such as “CAR BLACK BOX” and “SYSTEM USING IOT.” The system integrates multiple sensors, including a smoke sensor connected to ADC pin 26 for detecting gas levels, a fire sensor on GPIO16 for identifying fire hazards, and an IR sensor on GPIO17 for obstacle detection. Motor control is achieved through GPIO pins 2, 3, 4, and 5, enabling directional movements such as forward, backward, right turn, and stop functions. The program continuously reads sensor data within an infinite loop and applies decision-making logic: under normal conditions, the vehicle moves forward; when fire is detected, the system immediately halts the vehicle to prevent danger; when high smoke levels are observed, the system can trigger alerts or stop operations; and when an obstacle is detected, the vehicle changes direction or stops to avoid collision. The LCD dynamically displays system status, ensuring real-time monitoring. The results demonstrate that the system effectively enhances safety by detecting environmental hazards and autonomously controlling vehicle movement, making it suitable for applications in smart vehicles, accident prevention systems, and industrial safety automation. The developed IoT-based Car Black Box system

was successfully tested under different environmental conditions to evaluate its performance. During normal operation, the vehicle moved forward smoothly without any interruptions. When an obstacle was introduced in front of the sensors, the system accurately detected it and immediately stopped or changed direction, demonstrating effective collision avoidance. In the presence of smoke, the gas sensor responded quickly by detecting increased levels and triggering a safety action, such as stopping the vehicle and displaying a warning message on the LCD. Similarly, when a flame was brought near the fire sensor, the system instantly detected it and halted all motor operations to prevent potential hazards. The LCD display provided continuous real-time updates of system status, ensuring clear monitoring. Additionally, the communication module enabled data transmission, validating the IoT capability of the system. Overall, the results confirm that the system performs reliably in detecting hazards and responding appropriately

V. CONCLUSIONS

In today's world, the demand for automobiles is continuously increasing, leading to more traffic congestion and a higher risk of road accidents. However, when accidents occur, the response time to attend to victims can be lengthy, resulting in a greater number of fatalities. To address this issue, a proposed system incorporates various sensors, including a hall effect sensor for speed calculation, an accelerometer for detecting tilting conditions, a voice recorder for pre-accident voice recording, and a relay to activate the fan. Additionally, GPS technology is utilized to determine the vehicle's location. It is important to note that the system only functions once the GPS has started. By deploying this framework in moving vehicles, the proposed system aims to detect accidents and promptly report them in emergency situations. The recorded data, such as speed at the time of the accident, tilting conditions, and longitude and latitude information, can potentially save lives and provide valuable insights for accident investigations. Furthermore, the black box component of the system can capture the victim's voice after the accident, which can be utilized for further analysis. In the future, this system has the potential to be enhanced by incorporating additional modules and functionalities, making it even more robust and effective in accident detection and reporting. The existing system can be enhanced to include the monitoring of additional parameters such as fuel level, tire pressure, and the functioning of headlights. These parameters can be read and stored in the system's memory. Furthermore, an advantageous addition to the current system would be the incorporation of cameras on the front and sides of the vehicle. This would enable the recording of live images, which can be stored in the memory. The availability of stored video data would prove valuable for accident investigations and analysis purposes.

VI. REFERENCES

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