

IoT-based Vehicle Black Box with Cloud Analytics and Emergency Response (Car Black Box)

Avinash Pal
Assistant Professor, Electronics and
Communication Engineering
KIPM College of Engineering and
Technology GIDA, Gorakhpur, India

Shivsagar Patel
Scholar, Electronics and
Communication Engineering
KIPM College of Engineering and
Technology GIDA, Gorakhpur, India

Aanchal Paswan
Scholar, Electronics and
Communication Engineering
KIPM College of Engineering and
Technology GIDA, Gorakhpur, India

Abhinandan Yadav
Scholar, Electronics and Communication Engineering
KIPM College of Engineering and Technology GIDA,
Gorakhpur, India

Gajendra Chaurasiya
Scholar, Electronics and Communication Engineering
KIPM College of Engineering and Technology GIDA,
Gorakhpur, India

Abstract - The Road accidents are among one of the serious problems in 21st century and proper accident analysis is required to improve vehicle safety and emergency response. In this research project the 'Car black Box System' for accident analysis using IoT is designed to record important data related to the vehicle, driver and its surrounding conditions during an accident. Several sets of systems have been used with multiple sensors to monitor real-time parameters such as alcohol level in driver's blood, vehicle motion, obstacle distance and location. A MEMS sensor is used to detect sudden impacts and abnormal movements, while an alcohol sensor checks driver intoxication. Ultrasonic sensors help in monitoring nearby obstacles to reduce accident risk. A potentiometer and push-button switch are used to simulate vehicle speed and gear conditions for testing purposes. An APR9600 voice recording module is used to record audio data before and during an accident, which provides additional evidence, such as driver reactions and surrounding sounds. GPS and GSM modules are used to track the vehicle location and automatically send emergency alert messages. Sensor data is uploaded to the cloud using Node MCU for monitoring and future analysis. This system acts as a digital witness and helps in accurate accident investigation and improved road safety.

Keywords - Arduino UNO, GPS, GSM, APR9600, BLACK BOX, NodeMCU, MEMS sensor

I. INTRODUCTION

Road accidents are increasing day by day and have become a major concern for public safety. In such very cases, it becomes difficult to identify the exact reason for the accident due to a lack of proper evidence. The methods used Traditionally to investigate accidents methods mainly depend on eyewitness reports and manual inspection, which may not always be accurate. There comes a must need for an automated system that can record vehicles and driver-related important data during an accident. A car black box system works similarly to an aircraft black box by continuously monitoring and recording critical

parameters of a vehicle. Such systems will definitely give contribution in helping understanding the cause of accidents and provide reliable data for investigation, insurance claims, and legal purposes. With the advancement of embedded systems and Internet of Things (IoT) technology, it is now possible to design a smart and low-cost vehicle black box system with real-time monitoring capabilities. The proposed Car Black Box System for Accident Analysis using IoT is designed to monitor driver behaviors, vehicle movement, and surrounding conditions using multiple sensors. The system detects accidents using a MEMS sensor and records additional information such as alcohol consumption, obstacle distance, vehicle speed, and gear condition. To provide even stronger evidence, a voice recording module is included to capture audio before and during an accident. GPS and GSM modules are used to track the location of vehicle and automatically send emergency alerts. Sensor data is also uploaded to the cloud using IoT for further future analysis. This system tries to helps in accurate accident reconstruction, faster emergency response and importantly improved road safety. It acts as a digital witness by collecting reliable data at the peak time of an accident and can be easily implemented in different types of vehicles.

II. LITERATURE REVIEW

"Many researchers have worked on vehicle black box systems to improve accident detection and analysis. These systems are mainly designed to record vehicle data and provide useful information after an accident. As Gangad Monika et al. have proposed a car black box having system that uses IoT to monitor many vehicle parameters such as speed, brake status and even location. Their system helps in accident analysis and insurance investigation. However, the system mainly focuses on sensor data and does not include audio evidence, which can provide additional information during an accident". Lilia Filipova-Neumann et al. discussed the importance of vehicle black box systems in reducing information gaps in insurance

investigations. Their work highlights how recorded vehicle data can support fair claim settlement but there is a drawback in the system that it does not focus on real-time accident alerts or cloud-based monitoring. Thomas K. Kowalick has also presented the concept of event data recorders that is used for automobiles and explained their role in accident reconstruction. This research gives emphasises on the need of reliable data recording before and after a crash. However, the proposed approach does not include IoT connectivity or live emergency notification. Daesik Ko and Hwase Park designed an intelligent black box system that uses data analysis techniques for accident information processing. When it comes to the common vehicles their system improves data interpretation but requires complex processing and does not focus on low-cost implementation. From the above studies, it is observed that most existing systems focus mainly on sensor-based data recording and lack features such as voice recording, real-time cloud monitoring, and automatic emergency alerts. The proposed system in this research satisfies the gap and removes these limitations by using a variety of sensors, a voice recording feature, IoT-based cloud storage services, and GPS-GSM alert systems”.

III. BLOCK DIAGRAM

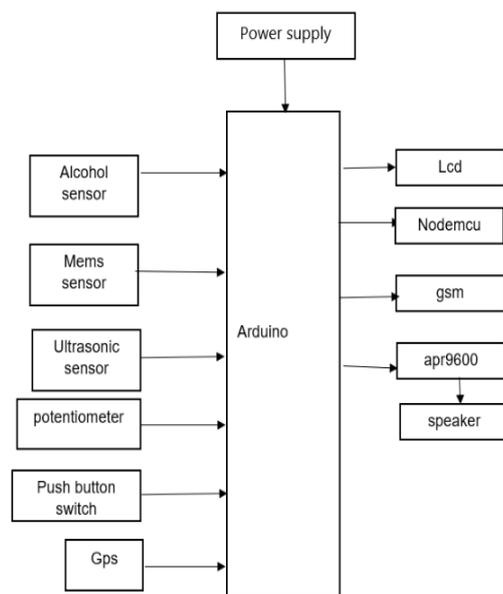


Fig. 1. Block diagram of Black Box System

A. Arduino UNO

In this case, the main controller of the entire system is Arduino. In this regard, the Arduino receives data from various sensors such as an alcohol sensor, a MEMS sensor, and an ultrasonic sensor. Subsequently, the Arduino is able to sense the accident conditions and control other modules.

B. LCD Display

The LCD display is used to show real-time information such as sensor values, system status, and alert messages. It helps the driver or user to monitor the working condition of the system inside the vehicle.

C. Alcohol sensor

The alcohol sensor detects the presence of alcohol in the driver’s breath. If alcohol is detected above a safe limit, the system can record this information for accident analysis. This sensor helps in identifying drunk driving conditions.

D. MEMS Sensor

The MEMS sensor is used for the detection of sudden changes in the acceleration and orientation of the vehicle. In the detection of accidents, the MEMS sensor significantly contributes in identifying the conditions of collision, rollover, and abnormal movements of the vehicles.

E. Ultrasonic Sensor

The ultrasonic sensor detects the distance between the vehicle and nearby obstacles. It is useful in monitoring the surrounding environment and can help in accident prevention.

F. Potentiometer

The potentiometer is used to give a simulated representation of vehicle speeds, which is required when carrying out tests as well as demonstrations. It basically provides varied input values to the controller, which is important in analysis, as shown in the diagram.

G. Push Button Switch

The push button switch can be used for simulating gear position or any event during testing. It provides a means for manual input into the system and assists in checking the system response.

H. NodeMCU

NodeMCU is being used for IoT technology. It sends the sensor data to the cloud with the help of Wi-Fi connectivity. This way, accident data can be stored for future analysis.

I. GPS Module

GPS module is employed for tracking the real-time position of the vehicle. During an accident, it sends important information on the correct latitude and longitude values.

J. GSM Module

The GSM module is used to transmit alert messages. The accident detection triggers a message containing the location details of the vehicle, which will then be sent to predefined phone numbers.

K. APR9600 Voice Recording Module

The APR9600 module captures audio prior to and at the time of an accident. The audio recorded may consist of reactions, alarms, and noise, helping in a thorough analysis of the accident.

L. Speaker

The speaker is connected to the voice recording module to play back the recorded audio when required. It also helps verify the recorded voice data.

M. Power Supply

The power supply unit provides all the required voltage levels necessary for the operation of all the components within the system.

N. 12V Adapter

The 12V adapter is used as a primary external power supply. It converts the AC voltage into an appropriate DC voltage level.

O. Connectors

Connectors find their applications in interconnecting different modules/sensors, which help in maintaining proper electrical connections, thereby making it easier for the system to be assembled and maintained.

IV. CONCLUSION

The project is designed for 'Car Black Box System' using IoT that can accurately record important information related to a vehicle before and during an accident as stated above. The system keeps track of the driver's condition using an alcohol sensor, monitors sudden movements through a MEMS sensor, checks nearby obstacles with an ultrasonic sensor, and collects location details through GPS. Whenever an unusual condition or accident is detected, the system immediately saves the data, starts audio recording, and also sends the location to the registered mobile number using GSM and most importantly all sensor readings are also uploaded to the cloud through NodeMCU so that the data can be checked anytime in the future. This makes the system useful for accident investigation, emergency response, and understanding the exact cause of the accident. At last we can say that the project shows how embedded systems and IoT can work together to improve road safety and provide reliable evidence during critical situations.

V. FUTURE SCOPE

For future references, this system can be improved in many such useful ways. A camera module also can be added so that photos or short videos of the accident spot can also be recorded along with the sensor data immediately. The GSM module can be upgraded to 4G/5G for faster communication, will be very helpful especially in emergency situations. The audio recording can also be extended to capture clearer surrounding sounds for better accident analysis. Machine learning or AI algorithms may be added later to automatically judge accident severity and predict risky driving behaviors. The system can also be connected directly to traffic control centers or hospital networks in future so that help can reach the accident location and provide add more quickly. With some improvements in hardware size and power consumption, this project can eventually become a compact module that can be installed in any vehicle as a standard safety feature.

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