El-Amin University Journal of Computing (EAUJC).
Vol. 1, Issue 1, April, 2024

Journal Homepage: https://www.eaujc.el-aminuniversity.edu.ng

AN INTERNET OF THINGS (IoT)-BASED ACCIDENT PREVENTION AND RAPID RESPONSE SYSTEM

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Abstract

Transportation has played a very important role in our daily lives and its development has made many of our chores much easier. With an increase in population in the recent years, there is an increase in the number of car accidents that happen every minute, some of which are caused by the use of alcohol by the drivers. Hence, there is a need to develop a system that caters for these problems and can effectively function to detect drunk drivers. The purpose of this paper is to introduce a system which helps in detecting alcohol usage and also notify an emergency unit as soon as any accident occurs. The system is achieved by integrating sensors with a microcontroller that can trigger at the time of an accident. The other modules like GPS and GSM are integrated with the system to obtain the location of the accidents and send it to an emergency number to notify them about the accident in order to obtain immediate help at the location. The performance of the system was checked using accuracy and response time in which an accuracy of 80% was recorded with a response time of 14.22 seconds. However, the system can further be worked on in order to improve the performance of the system.

Keywords: Accident Prevention, Road Accident, Car tracking, System, Detection, IoT

1.0 Introduction

Accidents are unplanned or unforeseen events causing injury or damage. From a legal perspective, the term accident can mean that the damage was not intended, and/or that the event cannot be regarded as involving a crime [1]. The frequency of accidents occurring worldwide has increased recently. The number of cars on the road also rises as the population grows, which contributes to the serious accidents that occur every day and could result in the loss of many lives. According to a survey conducted in 2013 by Hindustan Times in India, in every three minutes there is one death due to the road accidents in which 77% of accidents are due to manual mistakes [2].

The majority of emerging nations are the focus of daily traffic accidents. Lack of quick assistance that could save a person's life within a few seconds is the main factor in the death of a person during an accident [3]. All occupants of the vehicle are at risk for their lives the instant an accident occurs. Everything depends on how quickly they can react in order to spare them a few minutes or seconds of death. Statistics show that cutting the length of an accident delay by just one minute can result in a 6% reduction in fatalities [4]. Thus, in order to save their lives, this response time must be decreased or improved.

For modern society, the importance of accident prevention and alarm systems is highly important. Imagine that an accident occurred and that the emergency services were informed right away. This will enable the rescue of accident victims who are hurt [5]. In order for the solution to be functional, it must be able to track the location of the things at risk (in this case, automobiles) so

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Vol. 1, Issue 1, April, 2024
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that the ambulances can get at the scene in the shortest possible time [3]. Accidents caused by drunk driving still occur occasionally, despite the numerous efforts made by various governmental and non-governmental groups around the world through various initiatives to raise awareness against it [2]. However, if the emergency service had received the notice and crash information in a timely manner, many lives might have been saved. As a result, effective accident detection and prevention with automatic reporting of the accident location to the emergency services is essential to saving the priceless human life [2].

This paper describes the feasibility of equipping a vehicle with sensors that can detect accident and immediately alert emergency personnel. Usually, when there is a car accident someone has to actively seek help such as calling 911 for emergency services, there is no direct notification to the police, ambulance, friends, or family. These sensors can be used to trigger a notification and hasten response to the crash scene. The ambulance will use the Global Positioning System (GPS) coordinates from the notification to get to the scene quickly.

2.0 Related Works

[2], proposed a system for preventing and reporting road accidents using IoT technology through the use of sensors and cameras installed in vehicles to detect and report accidents to a cloud-based platform. The system and triggers an emergency response once the data has been processed. The system can provide valuable data for accident analysis and prevention efforts. The system has a limitation of not being responsive due to bad internet connection. Sharma, presented an algorithm for detecting car accidents and sending notifications to emergency services and designated individuals. The authors aim to improve road safety by utilizing the Internet of Things (IoT) to develop a system that can quickly detect accidents and provide fast response times. The algorithm uses data from various sensors, such as accelerometers and GPS, to determine if an accident has occurred and then sends a notification. The authors also perform simulations to show the effectiveness of the system in detecting accidents. This paper makes a valuable contribution to the field of road safety but it does not address the problem of accidents caused by drunk driving

[6], presented a system for detecting and reporting road accidents involving cars. The system uses sensors and a microcontroller installed in the car to detect accidents and send an emergency alert to first responders. The authors evaluated the performance of the system and found that it was able to effectively detect and report accidents in real-time. The authors also discuss the potential benefits of the system, such as reducing response times in the event of an accident and improving road safety. The system has a limitation of not being responsive in time in areas of low or no internet connection. [7], described a system for detecting and reporting road accidents involving motorbikes. The system aims to detect accidents and send an emergency alert to the concerned authorities and the rider's emergency contacts. The authors mention the use of sensors such as accelerometer and gyroscope to detect accidents. A GPS module is also incorporated in the device, which gives authorities information about the accident's location This system can be

improved upon by increasing the scope for it to work in cars.

[8], proposed a system for preventing and detecting road accidents using IoT technology. The system involves the use of sensors and cameras installed in vehicles to detect and report accidents to a cloud-based platform. The platform processes the data and triggers an emergency response, such as calling emergency services and providing real-time updates to first responders. The system also includes a smart brake control system that can automatically activate the brakes in the event of an imminent collision, helping to prevent accidents. The author concludes that the proposed system has the potential to greatly improve road safety by providing real-time monitoring and response to accidents.

[9], described the development of a smart helmet equipped with sensors such as accelerometers, gyroscopes, GPS, wireless communication and a microcontroller to prevent road accidents. The helmet is designed to detect dangerous riding conditions, such as high speeds or sharp turns, and alert the rider with sound and vibration signals. The authors evaluated the helmet's performance and found that it effectively improved rider safety. The system is good for a bike rider but does not help car users.[10], proposed a model that uses incremental clustering techniques to transform the raw data set into any number of clusters. These clusters roughly represent correlation among data points for several drivers, in drunk and in normal states. However, they do not provide any information about which cluster indicates what percentage of danger.

[11], proposed a system that senses the presence of alcohol consumed by the driver using the MQ-3 sensor. The nifty property of this sensor is that the range can be set up to 5-10 cm to sense the alcohol consumption of the driver alone and will thus be placed on the steering of the car. If the level of alcohol crosses the threshold value, the engine of the vehicle (DC Motor) is stopped and a short message is sent as an alert via GSM to the concerned authorities. The proposed system is slow and does not respond quickly. [12], offered adult drinking drivers and their passengers a free taxi ride home from drinking establishments or private settings where drivers could also receive a free return ride to retrieve their cars the next day, all in order to reduce the rate of drunk driving. The small sample sizes of safe riders' users in the current study limit the statistical power to detect significant effects

[13], offered a task for the tracking and management of cars using the SIM800 module that uses both the Global Positioning System (GPS) and the Global Mobile Communication System (GSM). The warning message is generated and sent to the car owner once the server receives the monitoring data from the GPRS and the GPS to determine the current location of the vehicle. The alert message of this system is sent to the owner of the vehicle instead of emergency or security services. Priya, proposed a system that uses technologies such as transmitter and receiver for getting information of sign boards or detection of speed breaker and GSR sensor to detect thedriver's emotions. From the conducted examination and analysis, they conclude that the system has various sensors and is efficient in terms of both the parameter as

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well as performance. The system is not cost effective.

3.0 Methodology

The system components comprise of different sensors that work with the microcontroller in order to detect accidents and drunk driving drivers. The design of the system consists of a microcontroller, accelerometer, alcohol sensor, GPS and GSM modules and alert systems as shown in Fig. 1. Fig. 2 is the breadboard implementation of the system

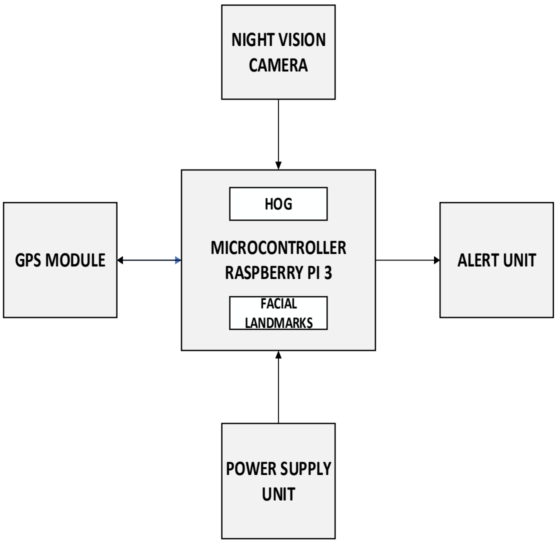

Fig 1: Overall System Block Diagram

1. Vibration sensors:

A vibration sensor is a type of sensor that is used to detect vibrations or movements in a machine. Vibration sensors can be used in the context of an accident prevention and alert system to detect changes in the movement or behaviour of a vehicle that may indicate an accident has occurred. The vibration sensor could then send a signal to the microcontroller, which could process the data and take appropriate action, such as sending an alert to activating emergency services.

2. Alcohol sensors:

Various alcohol sensors are available for detection of alcohol levels. They can detect the presence of alcohol in a person's breath or blood. In this context, an alcohol sensor could be used to detect if a driver has consumed alcohol and is above the legal limit to drive. The sensor can then trigger an alert if the driver's BAC is above the legal limit.

3. Accelerometers:

An accelerometer is a type of sensor that measures acceleration or the rate of change of velocity. Accelerometers can measure acceleration along one, two, or three axes, depending on the number of sensing elements present in the sensor. Single-axis accelerometers are commonly used in applications that only require measuring acceleration in one direction, while three-axis accelerometers are used in applications that require measuring acceleration in three directions (x, y, and z axes). The equation for getting the acceleration is given as:

$$\text{Acceleration} = \sqrt{accX^2} + \sqrt{accY^2} + \sqrt{accZ^2}$$

Where, accX equals acceleration on x axis

accY equals acceleration on y axis

accZ equals acceleration on z axis

4. Power Supply

Power supply provides electric power to a load. It supplies the required power to the circuitry the device. A 5v charger adapter connected to AC voltage serves as power supply to the raspberry pi. The camera is powered through the pi camera interface, while the buzzer and GPS module are powered through the raspberry pi's General Purpose Input Output (GPIO) pins.

5. C++ Programming Language

C++ is a powerful high-level programming language that allows developers to write efficient and optimized code that can run on a microcontroller with limited memory and processing power. In the context of this paper, C++ is used to write code that can read data from sensors like the accelerometer, process the data, and send alerts or trigger emergency responses when necessary. C++ is also used to implement algorithms for data analysis and decision-making, such as determining whether an accident has occurred based on the sensor data.

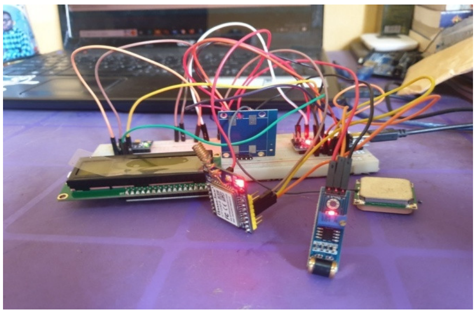

Figure 2: Breadboard Implementation

6. Working Principle of the System

Figure 3, shows the overall process flow in the system. The system starts by initializing accelerometer and alcohol sensor. The MPU6050 accelerometer and a digital (HIGH or LOW) vibration sensor were used where the accelerometer measures displacement on X, Y and Z axes and calculates acceleration based on equation (2.1). The accelerometer threshold was determined through experimentation that involves oscillating the system randomly emulating an accident scenario. It was determined that above $0.7m/s^2$, a car is not on normal acceleration level. Accident has occurred when acceleration exceeds the set threshold of $0.7m/s^2$ and vibration sensor of "HIGH" else it continuously reads the data.

Next, an alcohol sensor is used to determine whether alcohol is present in the vehicle and once alcohol is detected and exceeds a threshold of 500mL, the driver is drunk. The threshold is determined by the testing the alcohol in the air and it was observed that at 500mL, even with ventilation and other gases in the air, the sensor senses even a tiny bit of alcohol in the air. As shown in Algorithm 2, alcohol sensor data is gotten and once it gets to the set threshold of 500mL, driver is drunk else sensor keeps reading data.

The status of the system, that is, value of acceleration and reading of alcohol sensed is displayed on an LCD display and when an accident occurs or alcohol exceeds its threshold, it displays "Accident has occurred" or "Driver is drunk". The system uses the status from accident detection and drunk driver detection and if either is true, it generates alerts using the buzzer firstly and then the GSM module sends the location that has been detected by the GPS module to a designated number.

4.0 Result and Discussion

The results obtained from system evaluation are presented in Tables 1, 2, 3 and 4. The system was evaluated by determining the response time and accuracy of both the accident detection and drunk driver reporting units.

From the results obtained, which is summarized in Table 2 and 4, the system average response times were 12.80 seconds and 14.22 seconds for the accident detection and drunk driver detection units respectively. The accuracy of the accident and drunk driver detection systems were measured by was 86.67% and 80% respectively; hence, the system is effective in detecting accidents and drunk drivers.

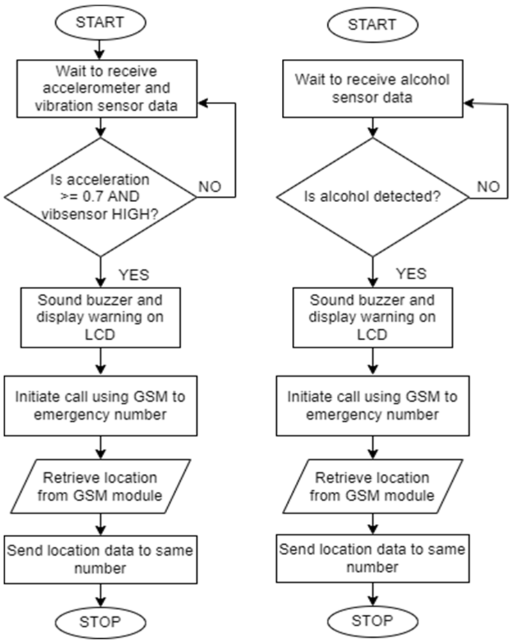

Fig 3: Overall System Flowchart

Table I: Accident Detection Results

Trial	TP	TN	FP	FN	Response Time (sec)
1			✓		6.94
2	✓				12.11
3	✓				18.60
4	✓				10.01
5			✓		12.67
6	✓				20.54
7	✓				10.62
8	✓				9.99
9	✓				15.42
10	✓				10.01
11	✓				10.98
12	✓				11.11
13	✓				13.60
14	✓				15.11
15	✓				14.40

Table II: Summary of Accident Detection Results

Performance Metrics	15 Test Trials
Accuracy	86.67%
Average Response Time	12.80 sec

Table III: Drunk Driver Detection Results

Trial	TP	TN	FP	FN	Response Time (sec)
1			✓		10.02
2			✓		8.96
3	✓				15.45
4	✓				12.44
5	✓				11.39
6	✓				13.40
7	✓				15.59
8	✓				18.55
9	✓				12.29
10	✓				14.99
11			✓		11.11
12	✓				18.22
13	✓				20.00
14	✓				16.89
15	✓				14.05

Table IV: Summary of Drunk Driver Detection Results

Performance Metrics	15 Test Trials
Accuracy	80%
Average Response Time	14.22sec

$$\text{Accuracy} = \frac{TP + TN}{TP + TN + FP + FN} \times 100\%$$

$$\text{Response Time} = TAD - TA$$

$$\text{Average Response Time} = \Sigma(TAD - TA)/N$$

Where TP is true positive
FP is false positive
TN is true negative
FN is false negative
TAR is time alert is received
TA is time of accident
N is number of samples used for testing

5.0 Conclusion and Future Works

The car tracking system is becoming more and more commonplace every day, not just in large cities but also in rural areas. This paper presents a vehicle accident detection and alert system with an SMS and call feature. The system was successful in the tracking of vehicles in the event of an accident and to achieve that, the GPS Module was used to retrieve GPS Coordinates of the vehicle and the location is sent to an emergency number via the GSM module. In this method, we can lower death rates by shortening the period of time between an event and its detection. It also detects and raises awareness of drunk driving.

Fixes either depend on specific hardware, like sensors that must be placed in the car and while using this hardware turns out to be more economical, it has the disadvantage of being damaged in an accident and providing inaccurate or no readings. In order to prevent this, a reliable solution that doesn't rely on any hardware or sensors is needed.

Further improvisations include installing a vision system for recording the activities of the driver. The controlling body can then utilize the recorded data to monitor adherence to the laws governingtraffic and safety. For improved communication between vehicles, it can be upgraded by putting the wireless transmitter on cars.

novel framework that combines the strength of ensemble machine learning with the capacity of PCA methods to reduce dimensionality. The experimental findings demonstrate that, in terms of accuracy and computing efficiency, the suggested method performs better than conventional machine learning models.

Additionally, sensitivity analysis was done to see how changing the number of primary components affected the accuracy of the estimation. The findings show that the number of principle components significantly affects the effectiveness of the estimation, and cross-validation techniques can be used to identify the ideal number of principal components.

Future studies should look at sophisticated feature engineering strategies and selection processes that can enhance the input data's representation. The performance of the ensemble model may be improved by incorporating new features or combining PCA with alternative feature selection algorithms. An adaptive PCA technique may help the model better capture and adjust to changes in energy usage patterns over time. Scholars may investigate how to combine PCA with other feature selection or dimensionality reduction strategies. Additionally, by investigating methods that allow the ensemble model to instantly adjust to shifting patterns of energy usage. It's possible that hybrid models, which integrate the advantages of several methods, perform better than PCA alone. By looking into how spatial and temporal patterns in energy

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