IoT-Enabled Alcohol Detection System for Road Transportation Safety in Smart City

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Abstract. In this paper, an alcohol detection system was developed for road transportation safety in smart city using Internet of Things (IoT) technology. Two Blood Alcohol Content (BAC) thresholds are set and monitored with the use of a microcontroller. When the first threshold is reached, the developed system transmits the BAC level of the driver and the position coordinates of the vehicle to the central monitoring unit. At the reach of the second BAC threshold, the IoT-enabled alcohol detection system shuts down the vehicle's engine, triggers an alarm and puts on the warning light indicator. A prototype of this scenario is designed and implemented such that a Direct Current (DC) motor acted as the vehicle's engine while a push button served as its ignition system. The efficiency of this system is tested to ensure proper functionality. The deployment of this system will help in reducing the incidence of drunk driving-related road accidents in smart cities.

Keywords: Internet of Things · Road transportation safety · Accident control Smart city

1 Introduction

Drunk driving is a very dangerous behavior because excessive consumption of alcohol causes distortion in thought pattern of drivers. The investigation conducted by the World Health Organization in 2008 shows that about 50%–60% of traffic accidents are related to drunk driving [1]. In present times, the cases of traffic accident caused by drunk driving has increased rapidly. It has, therefore, become evident that drunk driving does great harm to public security.

Different technologies and techniques have been adopted to reduce the incidence of road accidents due to drunk driving by motorists. The alcohol detector in [2] is made up of the alcohol sensor, Alternating Current (AC) power supply, LM 358 Operational Amplifier (Op-Amp), and Liquid Crystal Display (LCD) circuitry. This device displays

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the results of the alcohol sensor as it senses the alcohol molecules in air present around it, and displays a warning text when it crosses the fixed threshold set by the LM358 Op Amp. The drawback of this system was that it required whosoever to be tested to be close to the AC power outlet due to the system running on AC power. Also, the LM358 op amp which was acting as a comparator in the circuit and came with a preset value 5 for the threshold upon crossed, had no response such as an alarm to warn that the threshold has been crossed. This system was required two participants i.e. one person to carry out the testing and note when the threshold is crossed and the other as the person being tested. This system was nowhere close to proving a means of inhibiting a driver if he/she were drunk not to mention real time implementation [2].

James and John [3] proposed an alcohol detection system that alerts the driver through his/her cell phone. The major components of this system was the GSM module and the LM358 module. This system was a huge advancement from breath analyzers as it was based on GSM technology using the GSM module and dumped the use of an alarm circuit but still employed the LM358 Op-Amp. The system alerted via text messages using a GSM module and had a unique ringtone for such text messages set on the cell phone. Its major demerit was the lack of an LCD unit and an alarm circuit which could be useful in cases where the driver is not in possession of his/her phone. Another drawback is the presence of the LM358 Op-Amp as a comparator instead of using a microcontroller to allow for flexibility in changing the blood alcohol concentration (BAC) threshold due to probability in changes of body chemistry of the driver. The issue of cellphone batteries running down also comes up implying that the system would be inactive in the state that a cellphone battery is dead. Also, with most drivers in the habit of keeping their cellphones in the vibration or silent mode while driving, this inhibited the alerting property of the work [3].

Another alcohol detection system was developed in [4] based on PIC16F877A microcontroller. The presence of the microcontroller allowed for ease of manipulation of the threshold depending on body chemistry. The presence of the microcontroller gave room for addition of other features in the future. The only major drawback was the system's inability for a direct real time implementation due to it being powered by an AC power supply, as the alcohol sensor wouldn't have the opportunity to have at least 3 h full run in time it would get if on DC supply (vehicle battery) to give the sensor the degree of accuracy it requires for its operation [4].

Figure 1 shows the graphical representation of the fatalities and fatality rate for the past decades. We can see the decreasing order of the chart and as such we can deduce that in few decades to come and with the recommendation and implementation of our proposed embedded alcohol trigger device enclosed in cars that there might be no accident caused by drunk driving.

The aim of this paper is to reduce road accidents related to drunk driving to the barest minimum by using Internet of Things (IoT) technology. With the help of this system, drivers under the influence of alcohol can be detected, monitored, and tracked by relevant law enforcement agency in the smart city. The Internet of Things (IoT) is the most recent communication display in which the objects of regular day to day existence will be outfitted with microcontrollers, transceivers for digital communication, and appropriate convention stacks that will make them ready to speak with each other and with the clients, turning into a fundamental piece of the Internet.

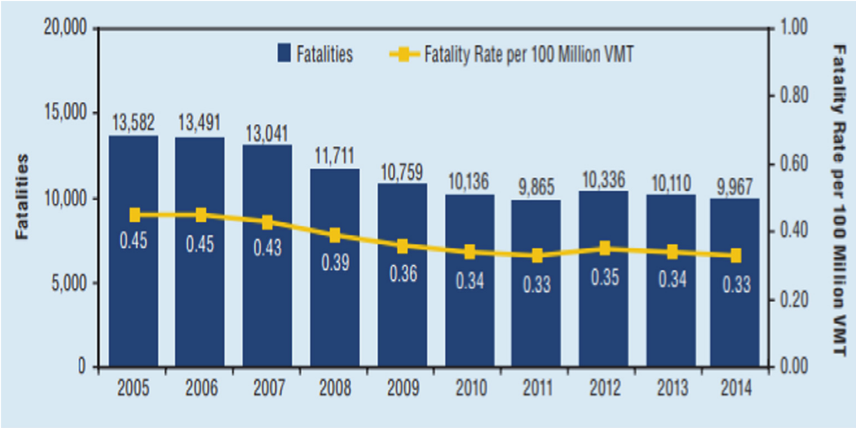

Fig. 1. Fatalities and fatality rate per 100 million VMT in alcohol-impaired-driving crashes, 2005–2014 [5]

This system is a very innovative system which will help to keep the roads free from drunk driving related accidents by not only shutting down the vehicle engine upon sensing the drunken state of the driver but would also help road traffic officials to be able to track down the vehicle inhabiting the drunk driver before the vehicle is shut down and allow for quick evacuation of the vehicle and the driver by the authorities so as to prevent traffic on such road.

The system is divided into sections; the interlock section and the monitoring section. The interlock section is made up the MQ-3 Sensor (alcohol sensor) which senses the alcohol molecules in the air breathe by the driver, an ATMEGA 328P microcontroller, a buzzer, an LCD screen, LED, Wireless Fidelity (Wi-Fi) modem, DC motor, Global Positioning System (GPS) and a push button as the ignition key. The monitoring system is a webpage built to view the BAC concentration levels of the driver as well as the coordinates of the vehicle. The system is powered by a 12-V DC source. The system has two thresholds, first (pre-drunk threshold) for communicating the BAC level and coordinates of the vehicle to the monitoring system and the second (drunk threshold) for shutting down the engine of the vehicle.

2 Materials and Methods

The IoT drunk driving monitoring system is a groundbreaking system with huge application I the field of smart cities and smart transportation. The system monitors the unsafe BAC levels and coordinates of the driver while in a drunk state through a web page. To make this possible, the hardware section of the system positioned in the vehicle makes use of the MQ3 sensor (Alcohol sensor) which senses the alcohol molecules in the air around the driver to determine if the driver is drunk or sober. The system makes use of the Arduino ATmega 328PU microcontroller, LCD screen, GPS, buzzer, DC motor, and WI-FI modem for sending data. The hardware is powered by a

12-V battery. The LCD screen used to display the BAC levels and coordinates of the vehicle. The GPS provides the coordinates of the driver's location.

A webpage is setup to show the BAC levels of the driver and coordinates of the vehicle to the personnel monitoring it. The webpage gives a numerical view of the BAC levels and the coordinates of the vehicle as they change over time. The final coordinates of the vehicle's location is taken when the coordinates stop changing therefore implying that the device has shut down the vehicle at those coordinates due to the BAC levels of the driver crossing the second threshold of the system therefore indicating that the driver is in a drunk state. At this drunk stage, the alarm of the device in the vehicle is triggered.

Power Supply: A 12-V was employed in this project. This 12-V is then stepped down to 5-V by the voltage regulator circuit so as to power the microcontroller and the sensors as 5-V is required by the circuit for its operation.

Alcohol Sensor: The simple gas sensor - MQ3 is appropriate for recognizing liquor, this sensor can be utilized as a part of a breathalyzer. It has a high affectability to liquor and little affectability to Benzene. The affectability can be balanced by the potentiometer. Tin oxide (SnO2) is Sensitive material of MQ-3 gas sensor is, which has a lower conductivity in clean air. At the point when the objective liquor gas exists, the sensor's conductivity is higher alongside the gas concentration rising, utilizing a straightforward resistive circuit changes over difference in conductivity to the relating yield flag of gas focus.

Arduino Uno: Arduino is a microcontroller board in view of the ATmega328P. It has 14 digital in-put/yield pins (of which 6 can be utilized as PWM yields), 6 simple sources of info, a 16 MHz quartz precious stone, a USB association, a power jack, an ICSP header and a reset catch. It contains everything expected to help the microcontroller. Arduino Software (IDE) were the reference variants of Arduino, now advanced to more up to date discharges. The Uno board is the first in a progression of USB Arduino sheets, and the reference show for the Arduino stage; for a broad rundown of present, past or obsolete sheets see the Arduino record of sheets.

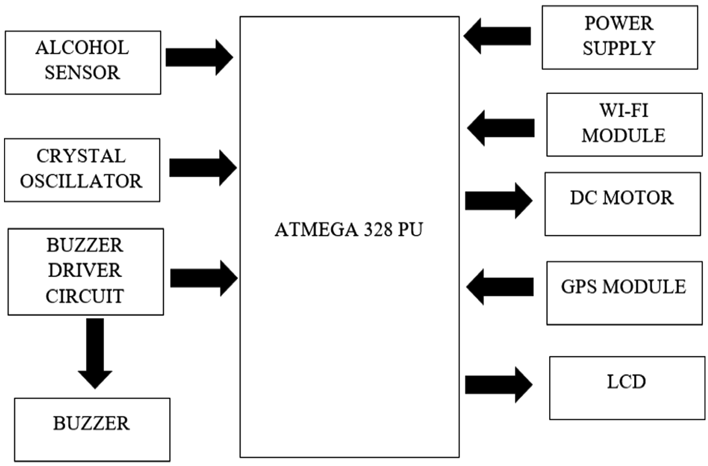

Fig. 2. Block diagram of the system

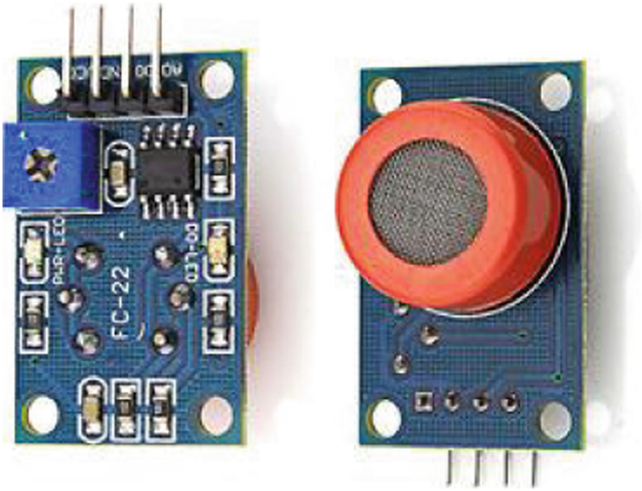

Fig. 3. MQ3 gas sensor

Wi-Fi Module: The ESP8266 Wi-Fi Module is an independent SOC with incorporated TCP/IP convention stack that can give any micro-controller access to your Wi-Fi arrange. The ESP8266 is able to do either facilitating an application or offloading all Wi-Fi organizing capacities from another application processor. Each ESP8266 module comes pre-modified with an AT summon set firmware. The ESP8266 module is a to a great degree financially savvy board with an enormous, and consistently developing, group.

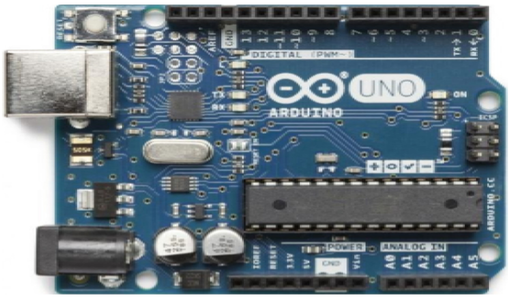

Fig. 4. Arduino Uno

GPS Module: The Neo-6M GPS Module is an independent GPS receivers including the elite u-box 6 positioning motor. They have a minimized design, power and memory alternatives. The GPS is a space based satellite route framework that gives area and time data in every single climate condition, anyplace on or close to the Earth where there is an unhampered observable pathway to at least four GPS satellites. The framework gives basic capacities to military, common and business clients around the globe. It is kept up by the United States government and is unreservedly open to anybody with a GPS recipient. The components of the developed system are shown in Figs. 2, 3, 4, 5 and 6. The flowchart and the circuit diagram are shown in Figs. 7 and 8 respectively.

Fig. 5. Wi-Fi Module

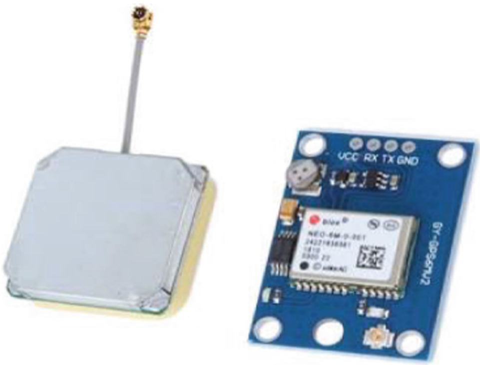

Fig. 6. GPS Module

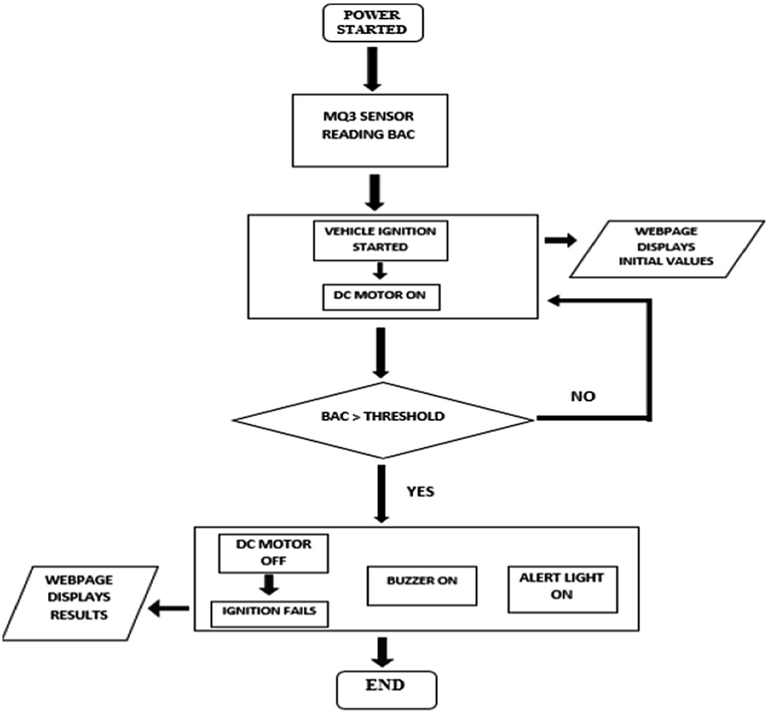

Fig. 7. Flow chart of system

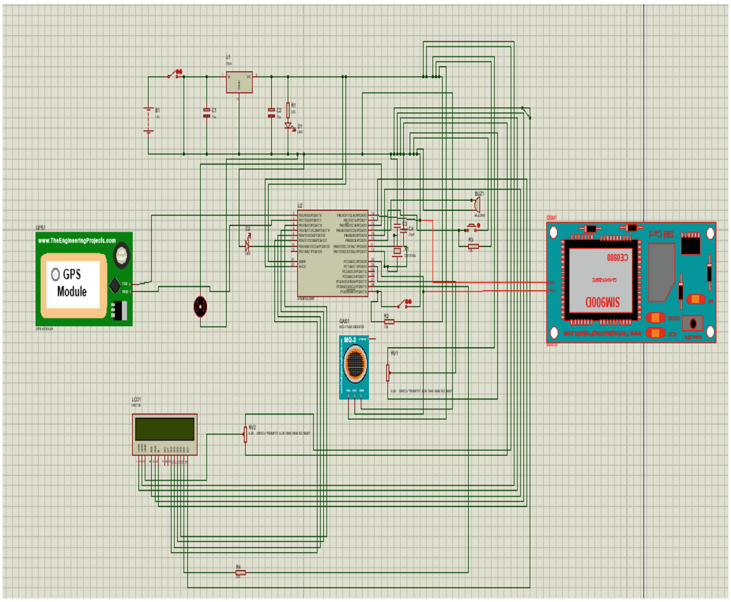

Fig. 8. Circuit diagram of the system

3 Results and Discussion

The developed system involved the use of ATMEGA 328P with Wi-Fi module. The embedded device is connected to the internet by the ADC and Wi-Fi Module. The alcohol sensor and GPS is connected to Arduino UNO board for monitoring. The ADC converts the corresponding sensor and coordinate reading to its digital value and from that value the corresponding environmental parameter will be evaluated. The sensed data (BAC levels & coordinates) is automatically sent to the web server, when a proper connection is established with server device. Table 1 shows the results taken from placing a specific volume of alcohol at specific distances from the MQ3 sensor as highlighted in Table 1. The analog value of the blood alcohol concentration at each distance is also gotten. The set threshold for the project was 244 (analog value) i.e. 0.5 g/l (BAC value). Figure 9 shows the graph of the blood alcohol concentration against the distance between the sensor and the volume of alcohol. It is deduced from the graph that as the distance increases the BAC & analog value decreases *i.e.* Distance between the sensor and the volume of alcohol is inversely proportional to blood alcohol concentration and the analog value.

Table 1. BAC (g/l) vs Distance (cm)

Distance (cm)	Analog value	BAC (g/l)
0	320	0.66
10	260	0.53
20	155	0.32
30	126	0.26
40	94	0.19
50	87	0.18

A few issues were experienced amid the task. The issues go from design issues to implementation issues and furthermore development issues. The significant issues are as per the following. The MQ3 sensor cannot differentiate between alcohol molecules and perfumes due to the presence of ethanol in both as the sensor reacts to any form of matter with high concentration of ethanol and as such a driver who is not drunk and has used a lot of perfume could trigger the system. The 9 V battery was not supplying enough current to power the circuit and the sensor at the same time. This problem was solved by using a 12 V battery instead of a 9-V battery. The buzzer was not loud enough when connected to the microcontroller alone, this problem was solved by connecting the buzzer to a transistor so as to amplify it as the microcontroller port does not have enough current to power the buzzer to operate at its normal capacity. The voltage regulator got was getting very hot due to the high amount of power dissipating as heat and as such leading to the voltage regulator switching off automatically. This problem was solved by attaching a copper heat sink to the voltage regulator. When the whole system was switched on, the LCD was not displaying any characters, this problem was solved by connecting a 10 K potentiometer to the LCD as it was used to tune the contrast of the LCD. Other problems include soldering and measurement errors but these problems were solved by proper troubleshooting with serious care in the construction of the project.

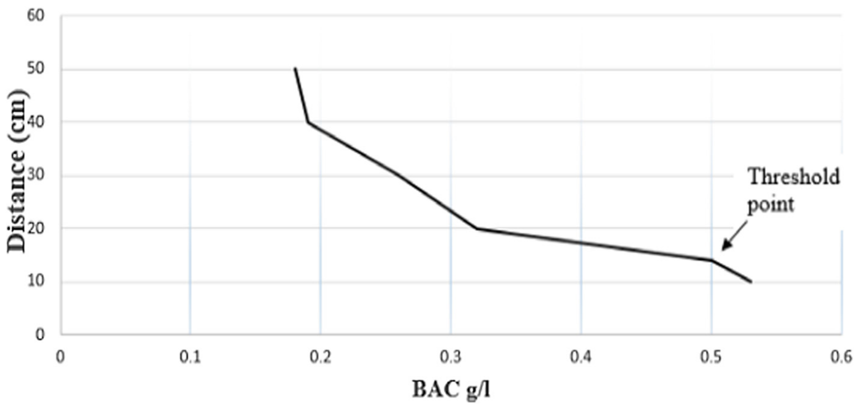

Fig. 9. Graph of blood alcohol concentration versus distance between sensor and alcohol

4 Conclusion

In this paper, an alcohol detection system was developed for road transportation safety in smart city using Internet of Things (IoT) technology. This system not only curbs drunk driving by automatically shutting down the vehicle that contains the drunk driver but also allows for traffic authorities to easily locate the shutdown vehicles using the coordinates of the vehicle sent to web server. The technologies which are used in the proposed system are good enough to ensure the perfect shut down and pick up of the drunk driven vehicle.

There are no projects that cannot be improved. Enhancements have to be carried out so as to improve the efficiency of this system. One of the improvements that could be made on this system in the future is that it should be made smaller. The smaller the system, the more convenient the alcohol system is, the more likely drivers will accept it. There should be proper positioning of the alcohol sensor so as to allow convenient reading of the driver's alcohol consumption quantity with or without the aid of the driver.

Some options for where the sensor can be placed include: (1) an element that can help differentiate the ethanol quantity in alcohol and perfumes should be introduced into the sensor so as to prevent the issue of the system being triggered due to use of large amount of perfume by the driver; (2) a cable can be put near the driver's seat and then connected with the ignition of the car. This means the alcohol detection system can be another key to the car. The driver should blow to the system before he/she start the car. If the value of the alcohol concentration is above the system's threshold value, the system will stop the car starting. So a drunk driver would not be able to start the car which will prevent the behavior of drunk driving. It is not only safe to the driver, but can ensure the passengers would not be hit because of the driver's drunk driving.

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