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Development of a Driver Safety Monitoring Device with Ignition Interlock

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ABSTRACT

Drunk driving and falling asleep on the wheel are the most prevalent causes of car accidents. We cannot ban individuals from consuming alcohol, but we can reduce the number of accidents by monitoring who is drinking and embedding safety devices in the car to ascertain that no one drinks and drives, and as well warn the driver if he or she falls asleep behind the wheel. This embedded safety system consists of an alcohol sensor, infrared sensor, motor, buzzer, and other devices that are all linked to the core microcontroller unit. An eye blink sensor was utilized to detect sleep by establishing a time limit; When the driver falls asleep. The system alerts him. The alcohol sensor detected whether or not the motorist is intoxicated. When he or she was too inebriated, the car issued a warning and the engine shuts down. Likewise, when the IR sensor detected tiredness in the driver or the alcohol sensor detected alcohol, the system notified the driver via buzzing sounds and a message on the Liquid Crystal Display (LCD) and the ignition locked further slowing the vehicle when the driver failed to respond to the alarm. The adoption of this embedded technology guarantees a method for monitoring a driver's tiredness and alcohol levels, thereby preventing car accidents before they occur.

1. INTRODUCTION

A driver-monitoring system is an advanced safety device that uses a sensor to detect driver weakness, burdensome, and drowsiness thereby alerting the attention of the driver. It is very important to incorporate a monitoring device in the car to aid in alerting the driver behind the wheel and create awareness of his movement thereby reducing the driver's distraction and increasing his focus on the highway which makes road users safer. This device monitors driver activities and helps to identify different behaviours like over-speeding, uneven braking, a sudden increase in acceleration, deviation from the road, and drowsing driving. In this study, we present a Driver Safety Monitoring Device as a means for improving automotive safety and security as well as people's safety in their various fields of occupations and environment through personal protective equipment [1, 2]. This device brings together Alcohol and Fatigue sensory devices. Driver weariness is becoming a key component in many car accidents. The danger inherit from drowsiness on motion is unprecedented whereby means of averting it must be established [3, 4]. There are dangers inherent in drowsiness. Drowsiness is a transitory condition between sleep and wakefulness in medical jargon. During sleep, vigilance is clouded and attention is diminished. This is regarded to be a major cause of accidents, particularly in vocations that need constant focus. The major modes of communication are roads and highways [5]. The protection of human life is critical. More financial losses are seen to be avoided as a result of risky conduct or mishaps. A Monitoring System is likely to eliminate one of the causes of tiredness.

Intoxication of drivers is currently a severe major concern nowadays that is expected shortly. In the near future, our method aims to decrease the amount of traffic auto-crash due to inebriation. Every thirty minutes, a person is killed in an accident caused by an inebriated driver behind the wheel of a motor vehicle. Drunk driving is a class A misdemeanor that has resulted in thousands of deaths in previous years. Driving under the influence differs depending on the state or nation where a person drives, but it is typically defined as operating a motorized vehicle when impaired by alcohol, narcotics, or another legal or illegal substance. Intoxicated driving is a prevalent and misunderstood problem. Many people who drive every day are unaware that the motorist in front of them at a red light may be inebriated.

This study describes the advances made in employing an alcohol detector, which is a device that detects changes in the level of occurrence of alcohol in the environment. It measures the alcohol concentration of a person's breath; this instrument is also known as a breathalyzer. The findings from this work showed that when the sensor detects alcohol in the car, it alerts the driver and on the other way round promptly locks the engine if he failed to heed the danger signal. The Infrared Red sensor monitors the driver's eyes and detects whether they are in an opened or closed position, if drowsiness is identified, the system sends a warning signal to the driver. It can calculate an eye closure time as the proportion of a time interval in which the eye is closed; if the driver's eyelids are closed for longer than the expected average time, the system infers that the driver is drowsy and alert in to prevent unforeseen circumstance to him and another road user.

Alcohol detection devices are primarily used to examine the concentration of alcohol in a driver's breath, while eye blink sensors are used to monitor the closing and opening of the driver’s eyes. A complete prohibition of alcohol is nearly impossible to enforce, just as constant surveillance of drivers by security or policing staff is nearly impossible. However, by incorporating a monitoring device that constantly monitors the driver's alcohol consumption and levels while also keeping an eye on the driver's tiredness level, the menace can be averted and aid the driver to operate under safety driving laws. If the vehicle’s ignition is connected to a monitoring system that includes an alcohol and sleepiness detection device, when alcohol is discovered in the driver's breath and/or appeared to be tired, the ignition will automatically turn off while the alarm system continues to alert the driver. If the driver is tired, this wakes him up or prevents him from driving while inebriated. Drastic increase in the number of motorists foster traffic congestion, thereby leads to increase in the number of accidents. The most common causes of car accidents are drunk driving and falling asleep behind the wheel. This is especially an issue in developing and underdeveloped countries like India and Nigeria, where traffic accidents have resulted in several unnecessary fatalities in recent years, with driving under the influence and sleep driving being the causes. Currently, sample cars are being tested off the roads and highways, but the process is manual and inefficient, and inspecting a drowsy driver is extremely tough. As a result, an alternative and more effective method of detecting drunk and sleepy driving might include the use of automated detection employing sensors.

This work creates a driver monitoring device that would monitor a driver's alcohol and sleepiness levels, if any of them were out of conformity with safety rules, notify the driver and, if necessary, deactivate the vehicle's ignition which prevents accidents caused by intoxicated drivers and motorist falling asleep on the wheel. This project addressed the issue of intoxicated and sleepy driving. Using an automated approach, and provided a new way to police drivers by continuously monitoring their alcohol and sleepiness levels and warning them if they exceed the legal limit. It also eliminated the need for security personnel to scrutinize automobiles off the highway at random. It increases road safety since a drunk driver is a hazard to himself and other drivers [5]. The research offered the hazards inherent in drunkenness and drowsiness, and the monitoring devices system built to prevent its consequences while plight the road.

2. LITERATURE REVIEW

2.1 The 1900s studies on drunkometer and breathalyzer

In the 1900s, there are previous studies on driving inebriation by some authors who researched the prevention of auto-accident caused by the drunkenness of drivers using a drunkometer and breathalyzer. These are shown in Table 1.

Table 1. List of previous studies on drunkometer and breathalyzer

S/N	Author	Year of Invention	Title	Contribution	Limitation/Gap	Ref.
1	Emil Bogen	1927	The diagnosis of drunkenness - A quantitative study of acute alcohol intoxication	He analyzed both blood and breathe to detent the alcohol content present in them and discovered that breathing gave a good predictor of the inebriation	Extreme in terms of blood as it dealt with alcohol concentration in the excretion	[6]
2	Roller N. Harger	1931 1936	Drunk-o-meter and Breathalyzer	He invented the drunkometer in 1931 to test intoxicated drivers He patented the drunkometer, a balloon-like device into which people would breathe to determine whether they were inebriated	The device is complicated to use and its operation requires strict supervision and constant retraining	[7, 8]
3	Richard L. Holcomb	1938	Alcohol about Traffic Accidents	He studied the dangers of drinking and driving using the drunkometer	His research was conclusive, it was limited to the use of the drunkometer	[9]
4	Robert F. Borkenstein	1953	Drunk-o-meter and Breathalyzer	He collaborated with Harger on the drunkometer and invented the Breathalyzer	It relies on wet-chemical methods that aren't accurate	[7, 8]
5	Richard Harte	1970s	Breath Testing for Prosecutor	Harte created the first breath alcohol-testing equipment using infrared spectroscopy in the 1970s	The conversion was tough to comprehend	[10]

Dr. Emil Bogen in 1927 began researching whether inebriation could be properly assessed. It had already been proven that assessing blood offered a decent measure of how inebriated a person was, but Bogen discovered that by checking both blood and breath, a person's breath was a reliable predictor level of alcohol through the analyses of the breath [6].

Bogen's research was expanded upon by a professor at Indiana University School of Medicine. Harger developed drunkometer (Figure 1), a breath-testing instrument that was ultimately successful, in his early 30s [7]. The name stuck, despite its origins as jest. The drunkometer was a step forward in the fight against drunk driving since it was bulky and creative. A chemical solution was introduced after suspects blew into a balloon. The hue of the solution changed as it absorbed more alcohol. The device was complicated to use and its operation requires strict supervision and constant retraining [8].

Dr. R. L. Holcomb conducted an additional study into the dangers of drinking and driving using the drunkometer developed by Rolla Harger’s breath-testing device. Holcomb determined that the chance of causing an accident increased six times in blood alcohol content (BAC) of 0.100 and 25 times at 0.150 in a study involving over 2,000 individuals while his research was conclusive it was limited to the use of the drunkometer [9].

Figure 1. Drunkometmer (source: Dr. Rolla N. Harger)

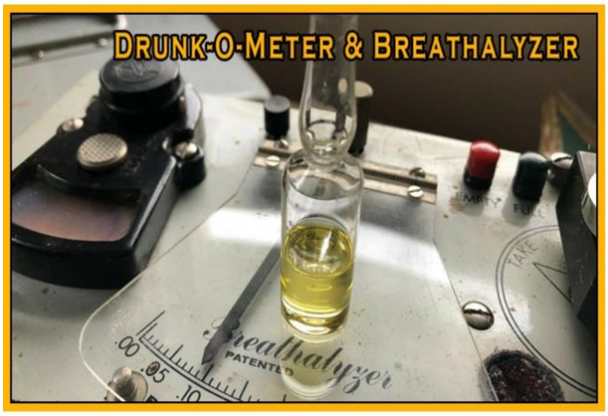

Figure 2. Drunkometer and Breathalyzer (source: Baltimore Police History)

Dr. Robert Borkenstein in 1954 invented Breathalyzer; his design was the first functional breath testing gadget (Figure 2). They made use of this instrument in the mid-1960s, which asserted Holcomb's findings and showed that a BAC of 0.08 and above significantly increases the likelihood of causing auto accidents. Breath alcohol vapours may be proportionately quantified by exhaling. The Breathalyzer equipment can estimate the quantity of alcohol in your blood, but it relies on wet-chemical methods that aren't accurate [6].

Richard Harte, an innovator adapted fuel cells to detect and measure alcohol in the breath. Mr. Richard Harte created the first breath alcohol-testing equipment using infrared spectroscopy in the 1970s. The infrared and fuel cell instruments were key technological advancements. This equipment, unlike the traditional wet-chemical approaches, detects and quantifies the physical characteristics of alcohol molecules themselves. Almost every contemporary instrument uses one or both of these techniques. The conversion was tough to comprehend. (At that time, all breath testing devices presented their results in terms of blood alcohol content [11].

2.2 The 2000s studies on Drunkometer and Breathalyzer

Several methods for this problem have been offered in numerous studies: Savania et al. [12] suggested a system that combines an alcohol sensor in a car with an ultrasonic sensor on accident-prone sites are received by the RF receiver, and the motorist is informed on the corresponding zones. Jha and Buva [13] created a model that attempts to prohibit users from driving when inebriated and cause a reduction in an auto crash or prevent auto accidents. Through the GSM module, the resulting information is sent by SMS to a nearby acquaintance. Malathi et al. [14] developed software in which an alcohol sensor was mounted on the steering to monitor the level of alcohol ditto the seat belt preventing the ignition from startup. Gbenga et al. [15] suggested a prototype that uses an Arduino-Uno microcontroller, an alcohol sensor, an LCD screen, and a DC motor to detect alcohol and activate an engine locking mechanism. If alcohol is found, the engine will be turned off and the vehicle must be parked immediately. Anthony et al. [16] proposed a device that is embedded in the steering wheel of a four-wheeler and detects the driver's alcohol level. The signal from the transmitter is sent to the receiver. If the driver is inebriated while driving, the sensor continues to measure until the amount crosses the limit, at which point the vehicle slows down and stops. A method for detecting alcohol that uses GPS and GSM was proposed by Shah et al. [17] but it is highly expensive. However, the costs can be reduced significantly to a large extent if a siren is being employed in Darshil's work it would be cost-effective and could keep individuals close observation.

Iversen [18] recommended the use of a smart helmet to avoid any mishaps, but it has several flaws, only two-wheelers are permitted to wear the helmet and the microcontrollers are software-based mega systems, whereas open-source hardware sirens are inexpensive.

Maheswari et al. [19] developed composite health monitoring and infrared sensors that were used to detect alcohol but has the limitation of false alarm. To prevent intoxicated driving accidents, Dhivya and Kathiravan [20] employed a PIC16F877A microcontroller, an antiquated and expensive system that is limited to a certain social class, whereas we are employing Arduino and Uno microcontrollers, which are both advanced and affordable. Concerned about intoxicated driving, the author proposes a solution to address the problem [21].

Having gone through works that have been done by other researchers, this work provided the advantage of using the MQ3 alcohor sensor because of its conductivity level. The build is smart and has an edge over MQ2. MQ3 is highly authentic than MQ2, which is not authentic and increases the risk of false alarms. Safety first is the key motivation in this work to prevent an increase in acceleration that could lead to accidents, risk of life and damage to the car.

Without this measure in control, the implication cannot be over-emphasized which invariably the cause of the phenomenon of the increased rate of accidents on the highways. Therefore, this present study is germane to society safety.

3. METHODOLOGY

3.1 Design methodology

The development of the system can be divided to cover two modules, namely: Hardware and Software.

(a) Hardware: This covers all the physical components used in this work. The System consists of 3 sensors. The MQ3 alcohol sensor, which detects ethanol, methanol, and benzene, is utilized in this research to determine the amount of alcohol in a driver's breath. The analog value is sent to the microcontroller and the values are measured in PPM [22]. The IR sensor monitors the driver's eye position to determine whether they are open or closed. A source and a receiver make up an infrared sensor. Infrared producers and detectors are both made up of photodiodes. This photoreceiver is connected to a potentiometer when blinking activity is detected; creating a voltage divider circuit that provides a changing analog output that is communicated to the Arduino UNO.

(b) Software: The software program package for use for driver safety monitoring is the Arduino IDE. This jot down and add packages to Arduino like-minded boards, however with the assistance of third-birthday celebration cores, and different seller improvement boards. Sketches are stored on the improvement laptop as documents with the record extension. Arduino IDE became created for humans and did not use profound information about electronics. Arduino IDE additionally consists of a message area, a textual content console, and a toolbar with buttons.

3.2 Material selection and description of the components

The following materials had been cautiously selected based on their distinctive characteristics and features of capability, capacity, length affordability, availability, and reliability. They include:

(i) Infrared Sensor: The version throughout the attention will range as consistent with the attentional blink. If the attention is closed the output is excessive in any other case the output is low.

(ii) MQ-3 Alcohol Sensors: The MQ-three module detects alcohol, which decreases conductivity in smooth air. It has excessive sensitivity to alcohol and has suitable resistance to disturb gasoline, smoke, and vapour. This sensor offers an analog resistive output primarily based totally on alcohol attention. When the alcohol exists, the sensor's conductivity receives better at the side of the alcohol attention rising concentration [23].

(iii) Buzzer: It is a beeper that is characterized by mechanical, electromechanical, or piezoelectric audio signaling devices.

(iv) DC motors are rotating electrical machinery that converts DC to electrical energy and mechanical energy. The most popular varieties rely on magnetic fields to create forces.

(v) Arduino UNO microcontroller: The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline package. The board is provided with sets of digital and analog input/output (I/O). The board has 14 digital I/O pins and 6 analog I/O pins and is programmable with the Arduino IDE through a kind B USB cable. It has one 5 V output pin and one 3.3 V output pin.

(vi) Connecting wires: These serve as connectors for the components.

3.3 Assembly of the driver safety monitoring device

The Arduino uno 5 V pin was connected to the positive terminal of the circuit while the ground pin was connected to the ground terminal of the circuit. The MQ-3 Alcohol sensor has four pins namely the Analog Output pin (Ao), Digital Output pin (Do), 5 V, and ground pins. The 5 V and ground pins were connected to their respective terminal in the circuits while the Ao pin is connected to the "A1" pin on the Arduino. This enabled the alcohol sensor to send analog readings to the Arduino. The Do pin was connected to pin 2 of the Arduino.

The IR sensor has three pins namely the output pin, Vcc, and ground. The 5 V and ground pins were connected to their respective terminal in the circuits while the output pin is connected to pin 6 of the Arduino. The buzzer has two pins output pin and the ground. The ground was connected to the ground terminal while the output pin is connected to pin 13 of the Arduino. There are two LEDs both of them are tied to 1k resistors and connected to pins 4 and 3 respectively. The LCD has 16 pins but it is connected to the I2C extension which brings the pin down to 4, SDA, SVA, Vcc, and ground. The 5 V and ground pins were connected to their respective terminal in the circuits while SDA and SVA were connected to A2 and A3 respectively.

3.4 Operational principle of the driver safety monitoring device

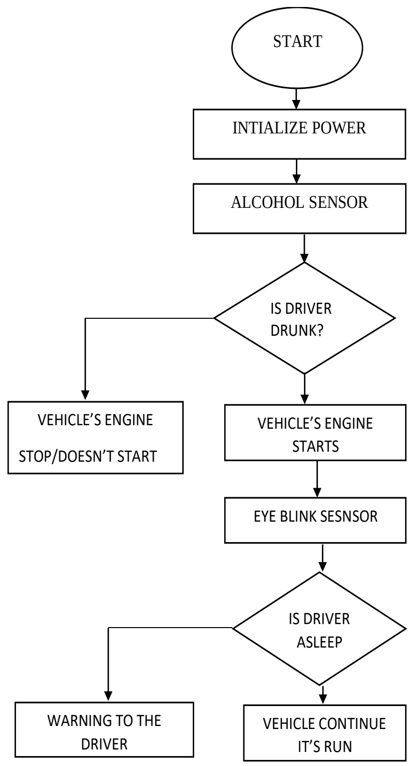

Figure 3. Flow chart of the operational principles of the driver safety module

The driver safety monitoring device works in such a way that once the driver attempts to start the ignition, he or she will be required to breathe into the alcohol sensor for his Breath Alcohol Content (BrAC) to be measured [24] and if it is within the legal limit the vehicle engine will start, but if the driver BrAC is above the legal limit the engine will not start. Then during the course of driving, if the driver is drowsy the driver will be notified via the alarm systems and the LCD, but if not the vehicle will work as intended, If the driver BrAC passes the legal limit during the drive warning sounds will go off to notify him, so then during the drive, if the driver mostly is drowsy the driver will be notified via the alarm systems and the LCD but if not the vehicle will work as intended, which essentially showed that then during the drive, if the driver is drowsy the driver will be notified via the alarm systems and the LCD but if not the vehicle will work as intended. The operational principle of the driver safety module is shown in Figure 3 while the circuit diagram is shown in Figure 4.

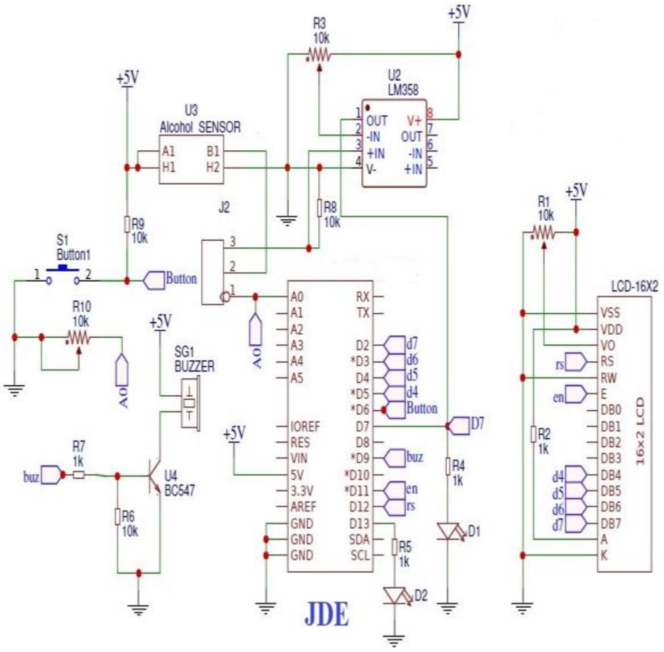

Figure 4. Circuit design for driver safety monitoring device

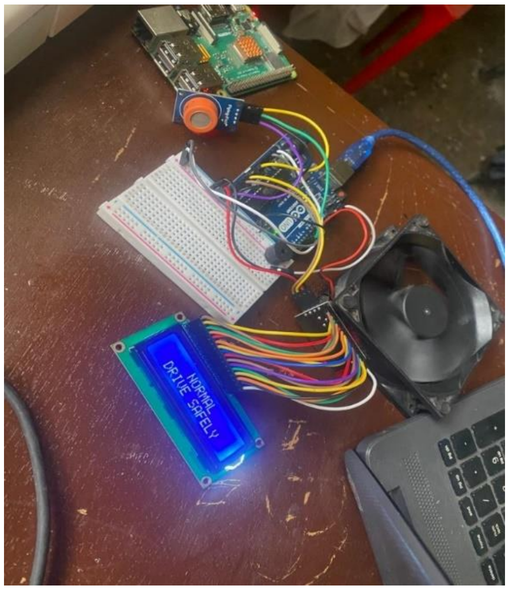

Figure 5. LCD displaying "normal" when no alcohol is detected

4. RESULTS AND DISCUSSION

The driver safety monitoring system was subjected to testing to determine the effectiveness of the alcohol sensor, IR sensor, fan module, and effectiveness of sensors system code. The fan module was put through the test in a variety of conditional scenarios that were simulated using the most appropriate sensors, to see how effective, the system is in controlling the fan module when system conditions are mostly met or not.

The system's power is used to switch on the device. The first test is an alcohol detector test, in which when the ignition that is on, should turn off when alcohol is detected by placing a bottle cap of methanol right in front of the MQ-3 sensor. The next test is the eye blink detection test, in which the glasses are worn and warning signals are activated when the driver's eyes are closed.

After undergoing the testing processes above for all intents and purposes multiple times, of positive results are gotten from the system, all intents, and purposes contrary to popular belief. The driver monitoring device system worked perfectly as shown in Figure 5. When the system specifically was turned on it takes readings from the alcohol sensor and if the alcohol sensor was exposed to alcohol, the fan remained off, which indicates that the ignition will generally be locked on the buzzer was triggered and the LCD screen displayed BrAC reading and the text DRUNK. This will remain until the alcohol can no longer be sensed by the MQ-3 sensor, once that condition particularly has been fulfilled the fan will, for the most part, turn on. The system will now start reading from the IR and alcohol sensors if any of them detects drowsiness or alcohol in a big way. The driver will be notified using the alarms. And the LCD will read WAKE UP if the driver is drowsy but if the driver is drunk it will display BrAC reading and the text DRUNK. During the test whenever the IR sensor detected drowsiness the buzzers essentially were triggered and the LCD screen displayed a BrAC reading when none of the sensors detected anything the LCD screen displayed "normal", drive safely.

5. CONCLUSIONS

The driver safety monitoring device, which includes the MQ-3 alcohol sensor and the infrared sensor, was featured in this work. It is used to keep track of a driver's alcohol and drowsiness levels. The following results were obtained after the design, assembly, coding, and performance evaluation. When the MQ-3 sensor detected the alcohol, the ignition switched off which will bring the inebriated driver to a halt. In the same vein, the IR sensor detected drowsiness on wearing a glass shade which intends will alert the driver to wake up.

It is worth noting that the present study is different from the previous studies as it combined an MQ-3 alcohol sensor and infrared sensor which contributed immensely to the body of knowledge in terms of the application to detect the inebriation and drowsiness of the drivers thereby alerting them of the danger ahead and prevent an accident.

6. LIMITATION

There is no limitation to this study's design, construction and application.

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