IJCAT - International Journal of Computing and Technology, Volume 7, Issue 1, January 2020
ISSN (Online) : 2348-6090
www.IJCAT.org
Impact Factor: 0.835

Principles and Policies for Development of a Breathalyzer-Enabled Ignition System for Reduction of Road Fatalities in Trinidad and Tobago

Marcus Lloyde George

Department of Electrical and Computer Engineering, University of the West Indies
St. Augustine, Trinidad and Tobago

Abstract - A modern motor vehicle is a complex piece of equipment utilized by millions worldwide for transportation between two or more locations. Despite the many advantages of motor vehicles it is the primary source of road fatalities. Operating a motor vehicle while intoxicated is one of the leading causes of vehicular road accidents worldwide. Many technologies, and policies for their use have been developed and placed into practice for minimization of road fatalities caused by driving while intoxicated, however none is without drawbacks. There is need for a novel breathalyzer-enabled approach with advantages addressing the drawbacks of the technologies that exist. This paper briefly reviews some existing technologies which attempt to minimize driving while intoxicated. A novel breathalyzer-enabled ignition system is then briefly proposed for reduction of the possibility of driving while intoxicated by drivers. Finally, policies are proposed for the secure use of the technology proposed.

Keywords - FPGAs in Automotive, Breathalyzer Systems, Breathalyzer-Enabled Ignition, Vehicle Ignition Systems, Intelligent Ignition Systems, Reduction of Vehicular Accidents

1. Introduction

The global status report on road safety [1] indicated that there is a continuous increase in road fatalities in the past decade, reaching 1.35 million in 2016. 20-50 million individuals obtain non-fatal injuries while many others obtain disabilities as a result of injuries obtained from road fatalities [1]. Vehicular accidents are common in most countries and many times they result in injuries, damage to properties and even fatalities.

According to [2], accidents may be caused because of several reasons, some outlined are speeding, reckless driving, distracted driving, driving under the influence of alcohol and driving under the influence of narcotics. Many countries are focusing on strategies towards reducing road casualties. Non-technological strategies such as speed limit signs, police patrol, and suspension of drivers' licenses continue to assist in reducing the number of accidents but have limitations. Technological automotive strategies such as adaptive cruise control, forward collision systems, adaptive headlights, traction control, electronic stability control and lane departure warning have also assisted in further minimizing the risk of road accidents [3]. Additionally, road surveillance via closed-circuit television (CCTV) cameras, used to monitor traffic and detect speeding vehicles are also helpful.

Driving while intoxicated increases the risk of vehicular accidents and also accounts for up to 35% of road fatalities [1]. According to [1] an intoxicated driver is over 16 times more likely to get involved in a road accident when compared to a sober driver. [1] indicates that the risk of accident varies with age and experience. A major breakthrough in combatting intoxicated driving is by setting legal and illegal blood alcohol limits, use of breathalyzer devices by law enforcement officials and implementing the use of ignition interlocks in vehicles governed by verification of drivers not exceeding blood alcohol thresholds.

This paper will explore existing approaches for combatting intoxicated driving, after which a novel breathalyzer-enabled ignition system is then proposed for significant reduction of the possibility of driving while intoxicated by drivers. Finally, policies are proposed for use of this novel breathalyzer-enabled ignition system.

2. Existing Technology-Based Solutions for Reduction of Alcohol-Related Accidents

[4] developed a breathalyzer device for controlling of the ignition switch of a vehicle. The hardware component of the system included the use of a PIC16F877A

microprocessor, LCD panel, blood alcohol sensor and an ignition switch system. The software system involved included the programming of the microprocessor. When assembled the system detects the alcohol concentration of a sample of a driver's breathe and depending of the value determined the system will enable or disable the ignition system of the vehicle. [4] did indicate that some technical and non-technical issues relating to the design of the system were experienced. The value of concentration of the blood alcohol sensor becomes saturated for BAC percentage more than 0.20 even though the alcohol concentration was more than that [4]. [4] stated that the breath alcohol sensor is cheaper, has low power dissipation and needs low input voltage between 3.3-5V. One negative of the sensor however is that it is capable of detecting substances other than alcohol, hence increasing the possibility of it misinterpreting those other substances as alcohol, however it has greater sensitivity towards alcohol.

[5] presented the development of an alcohol detection system capable of increasing the safety of derivers in a smart city using Internet of Things (IoT) technology. In this system two blood alcohol content (BAC) thresholds are defined and monitored with use of a microcontroller unit. While in operation of the first blood alcohol content threshold is reached the position coordinates of the vehicle driven along with the BAC level of the driver are transmitted to a central terminal which monitors the vehicles. When the second BAC threshold is reached the vehicle's engine is shut down by the the IoT-enabled alcohol detection system. The alarm on the vehicle is also enabled and warning indicators are put on.

[6] utilized a microcontroller, MQ303A alcohol sensor, ADC0809, LCD1602 panel, voice annunciator unit and a motor for speed control in the development of a breathalyzer enabled ignition system. The driver's breath alcohol concentration is measured by the MQ303A sensor and the corresponding voltage signal is passed to the ADC0809 for analogue to digital conversion. The microprocessor compares the digital signal to a predefined threshold value, and then signals the car motor. The car ignition is enabled when no alcohol is detected. However, when the blood alcohol concentration level is less than 20mg/100ml, the car ignition is enabled but the motor limits the speed to under the state's speed limit. At higher blood alcohol concentration levels there is greater limitation on the speed allowance for the vehicle, the vehicle does not start and a voice prompt is given out. One drawback of this system of [6] is that if the driver starts the vehicle sober and while driving becomes intoxicated, there is no action made corresponding to that situation.

[7] developed an advanced system to continuously monitor the blood alcohol concentration level in a vehicle with use of the MQ-3 alcohol sensor, GPS module, PIC18F25K50 microcontroller, normally-closed electromagnetic relay and the GSM modem. The GPS module would detect the location of the vehicle using position coordinates and the GSM modem would transmit this information via a SMS messaging to an appropriate security department. The MQ-3 sensor was calibrated using 30 users with different alcohol concentrations, each within a one (1) meter range from the sensor and inside a closed environment. The normally-closed relay would cut power to the ignition based on a signal from the microcontroller. The SIM900 GSM modem was used which had a RS-232 serial port and a baud rate of 115200 by default. A NEO6MV2 GPS module was utilized which used the NMEA0183 protocol, a RS-232 serial port and a baud rate of 4800. The PIC18F25K50 microcontroller was programmed in C using the CCS compiler. The analogue signal from the MQ-3 sensor was converted to a digital signal of 10 bits resolution. To set the threshold value, the sensor voltage corresponding to the alcohol concentration was determined from the calibration graph, and the decimal value of this voltage was programmed. This system of [7] was simulated using the PROTEUS software and a variable resistor used to simulate the working of the sensor. During implementation in 5 vehicles, the sensor was placed on the steering wheel as opposed to the seat belt. According to [7], this was done since the density of alcohol in the breath followed a perpendicular trajectory with respect to the driver. The performance of the system was evaluated using 30 users with different concentrations of beer (low, middle, high). A detection percentage of 84% was measured, with the error being due to factors such as open windows, air condition and passenger high alcohol level. At full operation the system consumed 0.95W and the alcohol level detection time was less than 100 ms. One drawback of this system of [7] is that it emulates the use of a vehicle but does not actually consider the use of an actual vehicle or model for use. Another drawback is that it does not consider the fact that contamination of the breath air can occur within the cabin of the vehicle itself.

[8] presented the development of system to be embedded on the seatbelt of a vehicle and would monitor the blood alcohol concentration of a driver. An ignition interlock system embedded in the vehicle would prevent an intoxicated driver from operating the vehicle, as long as the blood alcohol concentration is above the threshold. The system utilized a microcontroller along with a spectroscopic method of measuring blood alcohol levels. Currently, breathalyzers are used to determine the BAC level of drivers based on a partition ratio. This ratio is based on 2100ml of breath air having the same weight of ethanol as in 1ml of blood. It was argued that this

partitioning ratio posted a disadvantage to measuring accurate BAC levels since it may produce erroneous measurements and false indications of intoxication levels. [8] indicated that in this system the driver would place a finger through a hole in the sensor which contained a light source and spectroscopic detector. The light score and detector were on opposite sides of the finger, and a polychromatic light beam was emitted though the finger. The detector would measure the intensity of different wavelengths of light emerging through the finger and transmit this data to the microprocessor. Alcohol contains a sharp spectral absorbance at 1190nm, which would result in the intensity of light at this frequency being inversely related to the blood alcohol content. A high absorbance of light by the alcohol would result in a low intensity result at this wavelength, corresponding to high BAC level. The microprocessor used a statistical algorithm to compare the intensity information with the wavelengths emitted at the light source to determine the BAC level. However, depending on the amount of hematocrit in a person's blood, the absorbance of light would be different. Hence the system made consideration to this when applying the statistical algorithm. The detector was positioned and oriented to allow the driver to easily insert the finger, however it would be inaccessible to other occupants when the doors were closed and the vehicle was in motion.

Other methods exist, however all have their drawbacks that can how effective they are in reducing driving while intoxicated. There is a need to develop a breathalyzer-enabled ignition system which provides all benefits of existing systems and resolves the drawbacks of all existing systems. In the subsequent section of this paper will address this.

3. Proposal of a Novel Breathalyzer-Enabled Ignition System for Reduction of Alcohol-Related Accidents

The proposed breathalyzer-enabled ignition system will have blood alcohol concertation sensors installed on the seatbelts of the driver and every passenger seat of the vehicle. Alternatively, the blood alcohol sensors can be located above each driver seat, attached to the hood. The system must make use of Field Programmable Gate Arrays (FPGAs) for monitoring and control of the entire system. The proposed breathalyzer-enabled ignition system must meet the following specifications:

(a) Allows configuration of the system with blood alcohol concentration thresholds and at least three (3) contact numbers (must include a family member contact number, administrator contact number and police department contact number) which will be used in intercepting intoxicated drivers in control of vehicles, in the event driver is deemed to be intoxicated during commute.

(b) Fool-proof and capable of guaranteeing no intoxicated driver controls a vehicle. If breath-alcohol concentration level is above threshold the vehicle is not enabled for start and voice warning is made by the unit to all passengers of the vehicle. The vehicle should not be enabled to start using a passenger's breath. Even if a passenger sits into the driver seat and is able to enable the ignition, the instant the passenger removes themselves from the driver's space, the system would resample the breath of whoever is behind the driver seat and determine if the disable the ignition switch or not.

(c) Monitors the breath-alcohol concentration level on the driver side during journey and warns driver if level is within 20% below the threshold. If no action taken, then vehicle hazard light and horn must be switched on for alerting neighboring drivers.

(d) Monitors the breath-alcohol level on the driver side during journey if the level is within 20% below the threshold all listed contact numbers are sent warning messages and calls containing the coordinates of the intoxicated driver, so that they can be intercepted before causing harm via accident.

(e) Must include an evolutionary model in determining the true blood alcohol concentration state of the driver's breath. A vehicle cabin is open and the air in the section of the cabin in which the driver is seated is susceptible to contamination from other sections of the cabin. As such it is very possible that a driver may not be intoxicated, however a passenger in the vehicle may be intoxicated and the breath air from such passenger may contaminate the breath air on the driver side entering the blood alcohol concentration sensor, hence resulting in the proposed breathalyzer-enabled ignition system giving false positives. Alternatively, the driver may be intoxicated while all passengers are not intoxicated but because of the contamination in the cabin, false negatives can be made. This model should be taken into consideration in the development of this breathalyzer-enabled ignition system.

4. Policy Changes Possible with Proposed Breathalyzer-Enabled Ignition System

Several key policies must be taken into consideration with the introduction of this proposed breathalyzer-enabled ignition system. The purpose of these policies are to maximize the effectiveness of the system in minimizing the instance of driving by intoxication. Some policies for consideration are as follows:

(i) Mandatory Installing in all Vehicles

It is expected that the proposed breathalyzer-enabled ignition system can significantly reduce road fatalities by driving while intoxicated. Assuming this outcome is what is wanted, it must be made law and mandatory that all vehicles be fitted with the breathalyzer-enabled ignition system (at the expense of the owners of the vehicles) to add a supervisory component to the driving experience of all drivers.

(ii) All Drivers Must Wear Seatbelt

The blood alcohol concentration (BAC) sensor will be mounted on one of two places – either on the seatbelts or on the hood of the vehicle above the head of the driver and passengers. Once the BAC sensor is mounted on the seatbelt of the driver and passengers this will be the only avenue for measuring the BAC of the driver's blood. As a result, it must be mandatory that all drivers wear seatbelts.

(iii) Periodical Inspection of Breathalyzer Ignition System

The breathalyzer-enabled ignition system will be utilized for its supervisory benefit and if it is very effective in carrying out this function it will possibly be subject to malfunction and even tampering by drivers. It must be made mandatory that all installed units must be inspected periodically to ensure that they are fully functional or not tampered with. Making the device tamper-proof will further prevent the possibility of destruction. Tampering with the breathalyzer-enabled ignition system or failure to inspect on time should result in fines/penalties to owners of the vehicles.

(iv) Security of the Identity and Coordinates of Intoxicated Drivers

Care must be taken to ensure that the breathalyzer-enabled ignition system keeps the identity and coordinates of the intoxicated driver and vehicle secure and only revealed to the protective authorities who need it for intercepting an intoxicated driver in control of a moving vehicle.

5. Conclusions

This paper briefly reviewed some existing technologies which attempt to minimize driving while intoxicated. A novel breathalyzer-enabled ignition system was then proposed for reduction of the possibility of driving while intoxicated by drivers. Finally, policies were proposed for use of the proposed technology in reducing driving while intoxicated. It is possible that once the contents of this paper are considered and implemented that the possibility of driving while intoxicated will be minimized significantly.

References

[1] World Health Organization (WHO). 2018. "Road Safety - Alcohol." https://www.who.int/violence_injury_prevention. Accessed September 20, 2018.

[2] Pines Soloman. 2019. "Top 25 Causes of Car Accidents." Pines Salomon Injury Lawyers, APC. Accessed March 03, 2019. https://seriousaccidents.com/legal-advice/top-causes-of-car-accidents/.

[3] Agarwal, Himanshu. 2018. "How Does Technology Help To Reduce Car Accidents?" CEOWORLD Magazine. March 20, 2018. Accessed February 28, 2019. https://ceoworld.biz/2018/03/20/how-does-technology-help-to-reduce-car-accidents/.

[4] Rahim, H. Abdul, and S. D. S. Hassan. 2010. Breathalyzer Enabled Ignition Switch System. 2010 6th International Colloquium on Signal Processing & Its Applications (CSPA)

[5] Uzairue, Stanley, Joshua Oseheromomen Ighalo and Victor Olugbemiga Matthews. 2018. I. IOT-Enabled Alcohol Detection System for Road Transportation Safety in Smart City. Computational Science and Its Applications – ICCSA 2018, pp.695-704. DOI: 10.1007/978-3-319-95171-3_55

[6] Bao-hua, F., C. Q. Cheng, W. Dong, and L. Kai. 2011. "The automatic control system of anti drunk-driving," 2011 International Conference on Electronics, Communications and Control (ICECC), Ningbo, 2011, pp. 523-526. doi: 10.1109/ICECC.2011.6067708

[7] Barba-Maza, L. M., and C. Sánchez-López. 2016. "Development of a breathalyzer for car drivers," 2016 IEEE International Autumn Meeting on Power, Electronics and Computing (ROPEC), Ixtapa, 2016, pp. 1-4. doi: 10.1109/ROPEC.2016.7830528

[8] Bhatnagar, Smriti, Richa Gupta, and Kapil Kumar Singla. 2008. "Apparatus for Ensuring Seat Belt Usage and Checking Blood Alcohol Concentration." *2008 IEEE Conference on Robotics, Automation and Mechatronics*, 2008, 353-57. doi:10.1109/RAMECH.2008.4681330.

[9] Elder, Randy W., Robert Voas, Doug Beirness, Ruth A. Shults, David A. Sleet, James Nichols, and Richard Compton. 2010. "Effectiveness of Ignition Interlocks for Preventing Alcohol-Impaired Driving and Alcohol-Related Crashes A Community Guide Systematic

Review." *American Journal of Preventive Medicine* 40, no. 3 (2011): 362-76. doi:10.1016/j.amepre.2010.11.012.

[10] Win, David Tin. 2006. "Breath Alcohol Testers - Prevents Road Accidents." *AU Journal* 10, no. 2 (2006): 75-80. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwie-7nC_7XhAhUIrlkKHZM5BugQFjAAegQIARAC&url=http://www.journal.au.edu/au_techno/2006/oct06/journalTechV10N2_aticle01.pdf&usg=AOvVaw1toZEGlLhTpv6a3Xmbk7Fa.

[11] *Global Status Report on Road Safety 2018*, December 2018. Accessed January 10, 2019. https://apps.who.int/iris/bitstream/handle/10665/276462/9789241565684-eng.pdf?ua=1.

Author -

Marcus Lloyde George received the Bsc, MPhil and PhD degrees in Electrical and Computer Engineering from the University of the West Indies, St. Augustine in 2007, 2011 and 2019 respectfully. He is the author of 8 academic books, 3 life foundation books and over 40 papers to peer-reviewed journals and conferences. He is a multi-disciplinary researcher and some of his research areas include (but are not limited to) sustainable development, business administration, strategic planning and management, engineering education, smart/intelligent electronic instrumentation, formal specification, modelling and verification of digital electronic systems, consumer electronics and more.