Alcohol and Smoke Detection System to Combat the use of Drugs and Fire Incidents in Universities

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ORIGINAL RESEARCH

Abstract— Safety in university environments is a top priority, with drug and alcohol misuse and fire incidents posing major risks. Current safety systems do not offer integrated real-time detection for alcohol and smoke particles. This research fills that gap by developing an innovative system that detects both alcohol and smoke in real time, helping to address substance misuse and fire hazards on campuses. The system was developed using an experimental research approach that involved design, implementation, and rigorous testing. The hardware of the system comprises an Arduino-nano micro-controller, an electrochemical gas detection sensor for carbon monoxide (MQ-7), an alcohol vapour sensor (MQ-3), a clock module, and a cellular communication module (SIM800L). System calibration ensured accurate sensitivity and threshold values for detecting carbon monoxide and ethanol gases. Specifically, the threshold for the MQ-3 sensor was set at 90 ppm, while the MQ-7 sensor was calibrated to detect at 350 ppm of carbon monoxide. The system demonstrated an 85% accuracy for smoke detection, 80% for alcohol detection, and 70% when detecting both smoke and alcohol simultaneously. The average response time was 33 seconds for smoke detection, 32 seconds for alcohol, and 33 seconds for the simultaneous detection of both. The system's real-time detection capabilities provide a powerful tool for reducing drug and alcohol misuse on university campuses, while also offering a proactive approach to preventing fire hazards. This integrated solution has potential applications beyond campus settings, where the combined risks of substance misuse and fire incidents are also prevalent.

Keywords—Alcohol detection, MQ-3 sensor, MQ-7 sensor, real-time, Smoke detection.

1 INTRODUCTION

Basically, Alcohol and Smoke Detection Systems deal with public safety and well-being. These systems are extremely important in detecting the presence of alcohol vapors and smoke particles in different environments and alarming people about fire hazards and harmful substances. Alcohol- and smoke-related incidents pose a severe threat to life and property, as such incidents result in the rapid spreading of fire and produce smoke that has adverse health effects upon inhalation. There is, therefore, a strong need for the design of an alcohol and smoke detector system with the ability to sniff these threats with a view to early detection and prevention. This work is intended to extend such a sensor-enabled detection system capable of real-time air quality analysis, focusing on reliability, sensitivity, and efficiency for the best performance under varied environmental conditions.

The accelerating rate of drug and alcohol consumption among children is increasingly a cause of concern for educators, parents, and health experts (Hall *et al*., 2016). These are some of the factors that contribute to substance use, especially in higher learning institutions: peer pressure, easy access, and pursuit of confidence or for reasons of relaxation (Mugo, 2016; Tavolacci *et al*., 2013; Ham and Hope, 2003). However, it affects not only personal health but also academic performance as well as puts non-smokers in danger due to secondhand smoke exposure (Yang *et al*., 2021; Ho *et al*., 2010). Alcohol abuse represents a cause of many deaths and years of potential life lost among younger adults, and heavy drinking is causing a high percentage of preventable deaths in the U.S. (Georgieva *et al*., 2022; Weir, 2023). These immediate and long-term health risks associated with substance abuse outline the urgent need for comprehensive preventive measures and intervention strategies (CDC, 2022; American Cancer Society, 2023; Schulte and Hser, 2013).

In addition, universities worldwide have been including security measures such as surveillance cameras, security checks, and other disciplinary actions due to the increasing number of drug and alcohol consumption cases among the students. However, even this manner of control still finds a way for the students to bring prohibited substances into campus and, at times, get away with the authorities using private areas such as the student hostels.

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Section B- ELECTRICAL/COMPUTER ENGINEERING & RELATED SCIENCES

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The specific system this paper will put forward aims to provide a new intervention toward minimizing the use of drugs within university properties. With the aid of state-of-the-art gas sensors, it is able to detect gases generated by the consumption of alcohol and drugs. Accordingly, the system instantly triggers alerts to staff through real-time SMS messages with the location, date and time a particular incident occurred, as indicated by (Weir, 2023; Welsh *et al*., 2019). In addition, it blends into the environment and has made it tamper-proof, making it more effective in the execution of campus safety.

2 RELATED WORKS

Goyal *et al*., (2020) developed an IoT-based smoke monitoring system using machine learning to address public health concerns surrounding passive smoking. Their device, E-nose, employs gas sensors and an Arduino micro-controller to detect smoke, signalling smokers with visual and auditory alerts. Detected smoke data is uploaded to the cloud, where machine learning algorithms analyze pollutant levels and determine the percentage of smokers in the area. Ridwanullah *et al*. (2020) developed an IoT and face recognition-based cigarette smoke detection system to combat smoking violations in public areas, particularly in Indonesia, which has one of the highest smoking rates in the ASEAN region. Utilizing Raspberry Pi B+, MQ-2 gas sensor, GPS, and a camera, the system identifies smokers in prohibited areas and promptly notifies administrators, aiding enforcement efforts outlined in government regulations. Anthony *et al*., (2021) developed a system targeting alcohol detection specifically for drivers, aiming to address the high rate of accidents in India attributed to drunk driving. The system incorporates an MQ-3 alcohol sensor, akin to a car ignition switch, to detect alcohol levels surpassing a predefined threshold. Upon detection, the Arduino activates a GSM module to dispatch an SMS alert to authorities while simultaneously deactivating the car's ignition system via a DC motor, ensuring safety measures are promptly enacted.

Maheswari *et al*., (2022) introduced an alcohol consumption detection system integrated into a helmet, primarily aimed at reducing instances of driving with Blood Alcohol Content (BAC) above legal limits. The system utilizes IoT technology with Firebase as the database setup and Arduino as the embedded controller. Alcohol sensing is achieved through MQ-3 sensors, with the ESP8266 device facilitating connectivity to the Firebase database via Wi-Fi. Upon initiation, the system verifies the presence of a helmet and non-alcoholic breath before enabling vehicle operation. Additionally, a Bayesian learning model enhances alcohol detection efficiency while minimizing computational complexity.
Rhizma and Suhendar (2022) designed an IoT fire detection system to enhance residential safety by detecting and alerting occupants to fire incidents early. Utilizing an ATmega2560 microcontroller, PIR sensor for motion detection, and MQ-2 sensor for smoke detection, the system integrates with a smartphone app for real-time monitoring. Threshold values of 100 ppm for smoke detection and motion sensing trigger warning signals via the Blynk app, ensuring swift response to potential fire hazards.
Pertiwi *et al*., (2022) devised a cigarette smoke detection system using an MQ-2 gas sensor and Arduino technology, aiming to address the pervasive issue of cigarette smoke pollution in public spaces. The device employs a buzzer alert to indicate the presence of cigarette smoke, simplifying monitoring efforts in crowded areas, with a detection threshold set at 550 ppm. The other parts of the work were arranged as follows: section 3.0 is methodology, section 4.0 is results, and section 5.0 is the conclusion.

3 METHODOLOGY

The research approach used in this work is experimental. It involves the system design, implementation and testing of the system.

3.1 HARDWARE DESIGN

The design of the system was carried out using proteus software. The block diagram of the system's design is in Figure 1. The system has the following components as its sub-unit; an Arduino-Nano microcontroller, an MQ-7 sensor, an MQ-3 sensor, a clock module, and a SIM800L Module. The Arduino-nano microcontroller is the controller of the system. It coordinates all the activities of the system. Arduino-nano was chosen because it is easy to use. The MQ-7 is the sensor that senses the presence of smoke within the range of interest, while the MQ-3 sensor senses the presence of alcohol within the vicinity of the system. SIM800L module was responsible for the sending of SMS whenever the system senses either alcohol, smoke, or both within the prescribed circumference.

The circuit diagram of the system is presented in Figure 2. The Arduino Nano board receives signals from the sensors and activates the GSM module to send SMS to the registered number. An Arduino-nano has eight (8) analogue pins and fourteen (14) digital pins. Each of the Sensors used in this work has four pins namely; VCC, Ground, digital pin(D0) and analogue pin(A0). The clock module has five (5) pins namely; CLK, RST, VCC, GND AND DAT pins. The GSM Module used in this work is SIM 800L which has four pins namely; RX, TX, GND and VCC. Analog pin 0 (A0) and Analog pin 1 (A1) of the Arduino nano were used to connect the Analogue pins of the mq-3 and mq-7 sensors respectively. The digital pins of the Arduino Nano are used in this project to connect the clock module and the GSM Module to the Arduino Nano. Digital pin 6 (D6) and digital pin 2 (D2) were used in connecting the CLK and RST pins of the clock module. Digital pin 7 (D7) and pin 8 (D8) of the Arduino nano were used to connect the RX and TX pins of the GSM Module to the Arduino nano board. The VCC pin was connected to the 3.3V of the microcontroller, the GND pin was connected to the GND pin of the microcontroller and

the DAT pin was connected to digital pin 4 of the microcontroller. The clock module tracks the time in which the sensor senses ethanol and carbon-monoxide gas and its output is sent to the controller alongside the SMS to indicate the time of the incidence at which the sensor senses smoke, alcohol or smoke and alcohol.
The GSM Module requires a SIM (Subscriber Identity Module) to send SMS. The flowchart of the Alcohol and Smoke detection device is shown in Figure 3.

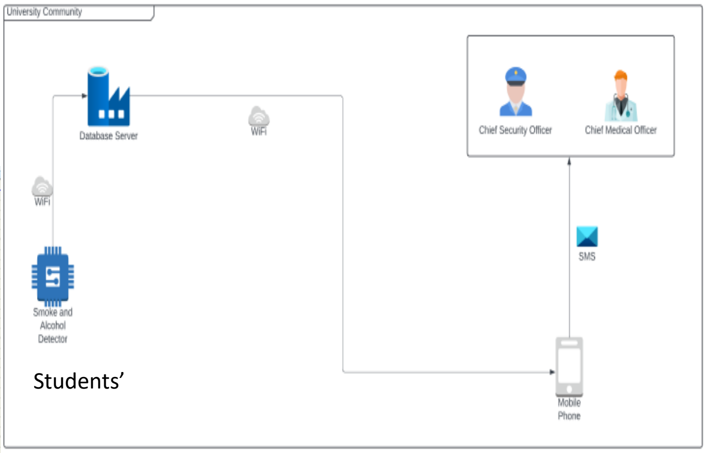

Figure 1: Architectural Overview of an Alcohol and Smoke Detection System

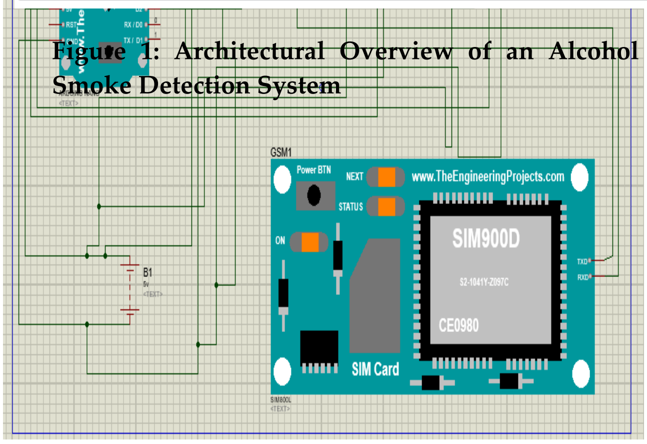

Figure 2: Circuit Diagram of the Alcohol and Smoke Detection System

3.2 SOFTWARE DESIGN

A software application was developed using the Arduino application, programmed in C language to control the microcontroller. The system's operation is outlined in a flowchart (Figure 3), depicting sensor and GSM module activities. Upon activation, sensors detect smoke or alcohol presence; if alcohol concentration exceeds 350 ppm or carbon monoxide surpasses 90 ppm, the GSM module triggers. SMS alerts are sent to designated recipients, namely the Chief Security Officer (CSO) and Chief Medical Officer, detailing the location and time of detection within the university. Collaboratively, the security and medical teams swiftly address the situation.

3.3 CALIBRATION OF THE SENSORS

Two sensors were calibrated to determine sensitivity and threshold values for carbon monoxide smoke and ethanol gas detection. Carbon monoxide's threshold value averaged over fifteen trials, was found to be 90 ppm, while the MQ-7 sensor's threshold was set to be 350 ppm based on the average value of Air without the presence of Alcohol. Sensitivity was adjusted based on sensor readings.

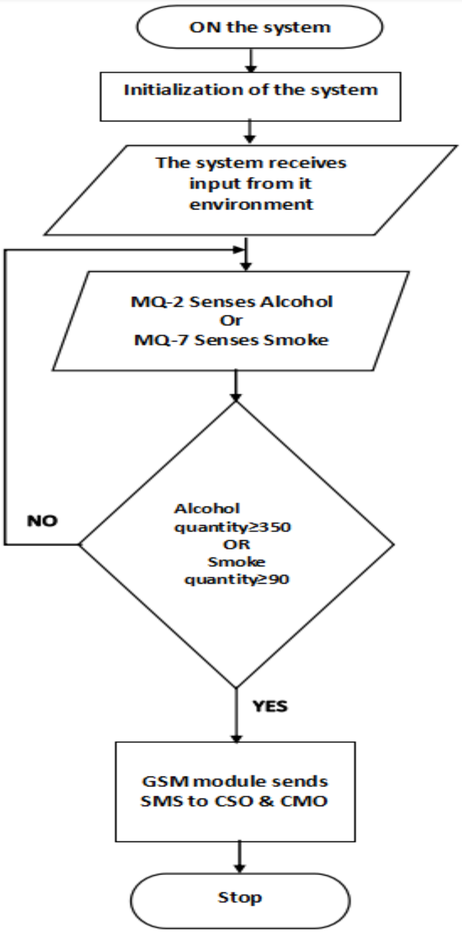

Figure 3: Flowchart of an Alcohol and Smoke Detection System

3.4 IMPLEMENTATION OF THE SYSTEM

The system design involved acquiring various components and assembling them according to specifications. Pre-coupling tests were conducted on a breadboard to ensure circuit functionality before final assembly on the Arduino Nano board. Figure 4 depicts the pre-coupling stage, followed by successful testing on a Vero board, resulting in the system with its casing, as shown in Figure 5.

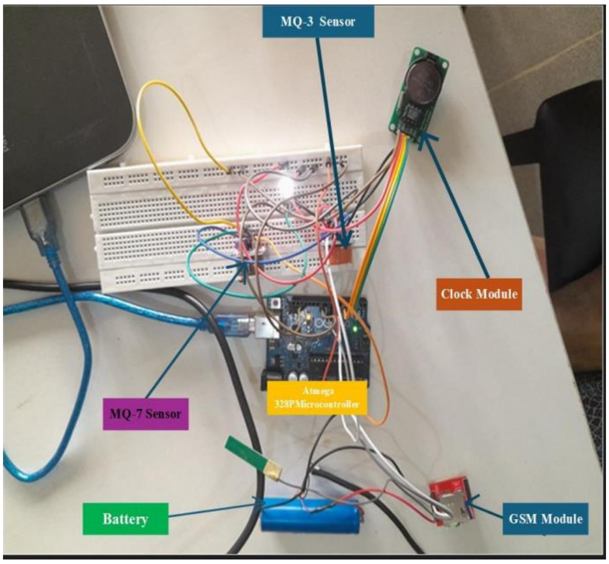

Figure 4: Pre-coupling stage of the system on Veroboard

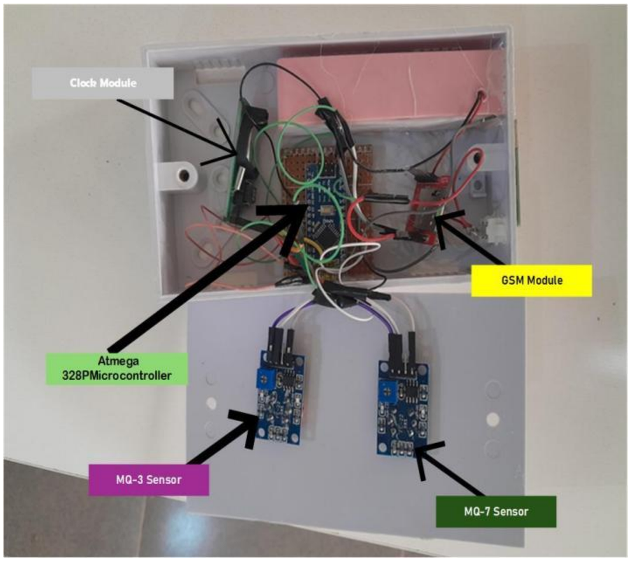

Figure 5: Pre-coupling stage of the system on it case

The packaged system is as in Figure 6. The system portal can be hidden in a strategic location within the student's hostel.

3.5 PERFORMANCE EVALUATION METRICS

Two metrics namely percentage accuracy and average time were used to evaluate this work. The percentage accuracy was calculated using equation (1), while equation (2) was used to calculate average response time.

Figure 6: The packaged system

$$\text{Percentage Acurracy} = \frac{TNS}{TNA} X\ 100 \qquad (1)$$

Where TNS represent the Total Number of Success, and TNA represent the Total Number of Attempt.

$$\text{Average Response Time} = \frac{TNRT}{NA} \qquad (2)$$

Where, TNRT is the Total Number of Alcohol Response Times, and NA represent the Number of Attempts.

4 RESULT AND DISCUSSION

During system development, testing took place in the rooms of Elizade University's female hostel 1, a single-story building. The system was installed approximately 3.2 meters above the ground floor, directly beneath the ceiling. Three rooms within the student hostel were utilized for testing purposes. Tables 1 and 2 present the system testing results, focusing on average response time and percentage accuracy. Specifically, Table 1 outlines calibration outcomes for the MQ-3 and MQ-7 sensors.

Table 1: Calibration Reading for MQ-3 and MQ-7 Sensors

Attempt	MQ-3 Sensor values for calibration reading		MQ-7 Sensor values for calibration reading	
	Value of clean air (ppm)	Air value with the presence of alcohol (ppm)	Value of clean air (ppm)	Air value with the presence of carbon monoxide (ppm)
1	204.00	401.00	57	75
2	205.00	404.00	62	87
3	119.00	402.00	54	67
4	154.00	408.00	51	90
5	190.00	408.00	54	92
6	194.00	411.00	53	82
7	195.00	413.00	47	76
8	199.00	419.00	57	94
9	203.00	425.00	58	77
10	245.00	512.00	52	69
11	234.00	523.00	51	78

12	123.00	578.00	56	63
13	90.00	619.00	55	99
14	345.00	611.00	53	111
15	330.00	615.00	49	126

From the values reported in Table 1, the threshold values for alcohol and smoke were set at 350 ppm and 90 ppm, respectively.

A Samsung Galaxy A04s (4GB RAM, 64GB ROM, 128GB Internal memory) 4G LTE Dual SIM smartphone with 4G GSM network of MTN Nigeria was used for testing. Figure 7 displays samples of the SMS the system sent out when it detected smoking, alcohol, or both. These were taken during system testing. The SMS includes the Room Number, Hostel Name, Date and time of the substance detection.

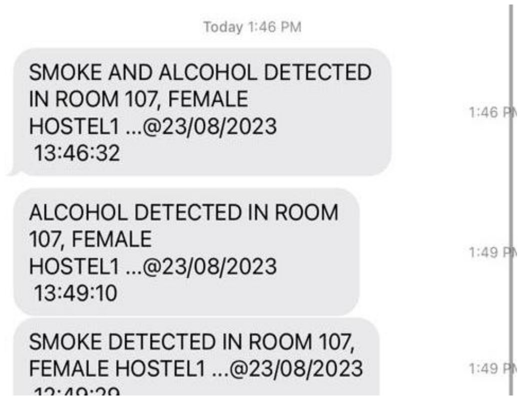

Figure 7: Samples of the SMS sent out by the system

Table 2, indicates the readings on the system's smoke detection status, the system's alcohol detection status, and the system's Alcohol and Smoke detection status in twenty (20) attempts. The Response time for detection of smoke, alcohol, and smoke and alcohol, in twenty (20) attempts were reported in Table 3.

Table 2: Record of Smoke Detection testing

Attempts	The system's smoke detection status	The system's alcohol detection status	The system's smoke and alcohol detection status
1	1	1	1
2	1	1	0
3	1	0	1
4	1	0	0
5	1	1	1
6	1	1	1
7	0	0	0
8	1	1	1
9	1	1	1
10	1	1	1
11	0	1	1
12	1	1	0
13	1	0	0
14	1	1	1
15	1	1	1
16	1	1	1
17	1	1	1
18	1	1	1
19	1	1	0
20	1	1	1

Note: 1 = substance detected, 0 = substance not detected

Table 3: Response Time for detection of smoke, alcohol and smoke and alcohol

Attempts	Response time for smoke detection (seconds)	Response time for alcohol detection (seconds)	response time for smoke and alcohol (seconds)
1	30	25	10
2	15	5	31
3	5	19	12
4	35	52	34
5	29	21	43
6	54	33	56
7	52	25	38
8	31	45	42
9	43	39	50
10	23	34	33
11	47	56	55
12	12	43	47
13	51	30	52
14	19	35	23
15	33	37	32
16	27	24	41
17	53	41	12
18	10	32	23
19	44	47	13
20	27	11	5

Equation (1) was used to calculate the percentage accuracy for the detection of smoke, alcohol, and smoke and alcohol as 90%, 80% and 70% respectively using the values in Table 2.

The average Response Time of the system to detect smoke, alcohol, and smoke and alcohol using equation (2) were 32 seconds, 33 seconds, and 33 seconds, respectively.

The current work offers significant advantages over Rhisma, (2022) study by providing detailed performance metrics, including accuracy percentages and response times for detecting alcohol, smoke, and their combination. In contrast, Rhizma, (2022), while demonstrating effective sensor integration and voltage readings, lacks the comprehensive evaluation provided by the present research, particularly in terms of quantitative performance statistics. Also, in comparison with Pertiwi *et al*., (2022), this study excels by delivering extensive performance metrics, ensuring a robust evaluation of the system's effectiveness. However, it would benefit from incorporating the level of detail seen in Pertiwi *et al*., (2022), particularly regarding the specific sensor types and threshold values used, to enable a more complete comparison and a deeper understanding of the system's capabilities.

5 CONCLUSION

The implementation of an Alcohol and Smoke Detection System for students' rooms, as demonstrated in this work, proves to be a crucial step towards ensuring the safety and well-being of students on campus. The integration of such a system addresses the potential risks associated with alcohol consumption and smoking within confined spaces, contributing to a safer living environment. The case study highlights the effectiveness of the system in monitoring and alerting authorities in real-time, enabling timely intervention in case of any hazardous situations. By leveraging modern technology, the Alcohol and Smoke Detection System acts as a proactive measure to prevent accidents, health issues, and fire hazards that may arise from alcohol or smoking-related activities. Future research should be explored to investigate energy efficiency, and sustainable designs and assess the system's impact on student behaviour regarding alcohol misuse and safety.

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