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Drowsiness and alcohol detection system using Arduino Uno

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Abstract

This applied experimental research focuses on developing a drowsiness and alcohol detection system using Arduino Uno technology. This device is intended for integration into glasses to be used by drivers to enhance road safety by combining infrared sensors for detecting drowsiness based on the duration of the user's blink, an MQ3 module for detecting alcohol in the breath, and an SMS system for emergency contact, all included in a single device. Descriptive statistical methods evaluate the effectiveness of the drowsiness detection system in terms of accuracy and eye structure, and the alcohol detection system is evaluated in terms of consistency and sensitivity regarding the amount of alcohol present in the user's breath. For the drowsiness detection system, accuracy is assessed by its ability to detect eyelid closure for more than three seconds using an infrared sensor, with consistent recorded performance regardless of eye structure. Concerning the alcohol detection system, consistency is evaluated over 30 tests, with slightly varying success rates depending on alcohol consumption levels (10 mL, 20 mL, and 30 mL), demonstrating good accuracy across all trials. Statistical analyses, including t-tests and ANOVA, reveal no significant differences in efficacy based on eye structure or the amount of alcohol. The researchers recommend improving the sensitivity of the Drowsiness Detection System, addressing errors in the Alcohol Detection System by further calibrating the sensitivity of the module, integrating a NEO-6M GPS module for more detailed location information, and improving the design of the product by using lighter variants of the parts used.

Keywords: applied experimental research, IR sensor, MQ3 module, GSM module, alcohol detection, drowsiness detection

Drowsiness and alcohol detection system using Arduino Uno

1. Introduction

In 2019, an estimated 10000 casualties were reported due to alcohol-related driving accidents, while drowsiness accounts for roughly 91000 crashes each year worldwide (National Highway Traffic Safety Administration, 2021). As society develops its infrastructure and more roads are paved across our cities, the number of cars on roads worldwide steadily increase as over 85 million cars will be produced in 2022 (Placek, 2023). Accidents involving the use of locomotives have become a concerning problem in the Philippines. The Philippine Statistics Authority (PSA) released data showcasing the 39% increase in annual traffic-related casualties from 2011 to 2021. In the span of a decade, casualties increased from 7938 to 11096. However, no impactful actions have been taken to aid in the prevention of these events. The study aimed to offer a solution that is cost-efficient and feasible. "Drowsiness and Alcohol Detection System using Arduino". This multi-purpose device has the intention of acting as a prevention tool to detect early signs of drowsiness and fatigue, while also having the capability to check alcohol levels in the breath. The proposed device also features safety precautions such as the ability to send an immediate SMS to a selected contact in case of an emergency.

Similarly proposed devices exist in the form of "Driver drowsiness detection" using infrared light cameras, while the study by Tamares et al. (2023) proves the feasibility of infrared sensors in the context of motion detection alongside infrared thermal detection. These devices primarily target occupations requiring extended periods of driving, such as freight deliveries, truck driving, and bus transportation. Notably, vehicle manufacturers like Tesla have integrated detection systems that monitor the duration of a driver's blinking for a similar purpose. However, this feature is exclusive to the vehicle itself, rather than being a device that can be mounted on any car. Alcohol detection is an important aspect of precautionary driving, breathalyzers are used by police enforcement to register intoxicated individuals, however, these situations only occur if authorities are alerted previously to an intoxicated driver. The advantage of having an alcohol detection system included in the device is the ability for the driver to check their alcohol level and conclude if it is above the legal limit or if it will cause impairing effects to the driving capability of the user.

The combination of a drowsiness and alcohol detection device has not yet been commercialized, and a working wearable product has not been conceptualized. With the use of the Arduino Uno, the researchers aim to fill this gap by creating a device that can detect the drowsiness of an individual and the current alcohol content of their breath, with the aim of creating a precautionary device to aid in preventing vehicular accidents.

Statement of the Problem - This study aimed to develop a location alert device using Arduino Pro Mini. Specifically, this research sought to answer the following questions: (1) What is the level of effectiveness of the location alert device as assessed by its users in terms of convenience, wearability, and user-friendliness? (2) What is the level of performance of the location alert device as assessed by its users in terms of battery life, speed; and accuracy? (3) Does the type of location affect the performance of the text function of the location alert device in terms of speed, and accuracy? (4) Does the type of location affect the performance of the call function of the location alert device in terms of speed and accuracy?

Significance of the Study - This research aimed to develop an effective Drowsiness and Alcohol Detection System Using Arduino Uno that would benefit the following entities: Drivers will directly benefit from the improved road safety brought by effective drowsiness and alcohol detection systems. The study's outcome can raise awareness among drivers about the importance of responsible and alert driving, fostering a culture of safety on the roads. Law enforcement agencies can use the findings to improve how they detect and stop impaired driving. Upgraded detection systems can help officers spot potential dangers on the road, enabling them to respond quickly and effectively. The general public will benefit from improved road safety. Creating effective drowsiness and alcohol detection systems contributes to safer roads for everyone. This project can serve as a valuable reference for future researchers and developers working on similar projects or seeking to improve tracking control systems.

Scope and Delimitation of the Study - This study focused solely on developing and testing a drowsiness and alcohol detection system using Arduino Uno. The efficacy of the device is evaluated in terms of its accuracy and consistency. It aimed to check how well two major components of the system worked: an infrared sensor for detecting drowsiness and an MQ3 module for detecting alcohol. For the Drowsiness Detection System, the researchers measured how accurately it could detect when someone's eyes closed for more than 3 seconds, taking into account various eye shapes (narrow and round eyes). Also, researchers looked at how consistent the Alcohol Detection System was over 30 tests and how well it detected different alcohol levels (10 mL, 20 mL, and 30 mL). And when there is drowsiness or/and alcohol detected by the user, the system sends an automated SMS to the user's contact person. Nonetheless, the study aimed to improve road safety by developing a practical solution for detecting drowsiness and alcohol levels with Arduino Uno technology.

2. Methodology

Research Design - The study's development involved the use of an applied-experimental research approach, which was helpful in developing workable ideas for the creation of a Drowsiness and Alcohol Detection System Using Arduino Uno. As a methodological strategy, applied research would carefully utilize prior knowledge to address real-world problems and produce solutions with concrete implementations. In applied research, a wide range of data-gathering techniques are used in conjunction with a careful blending of qualitative and quantitative approaches to guarantee a comprehensive investigation of real-world issues and the extraction of significant knowledge. In this study, the use of a quantitative research approach would be justified by the need for a thorough assessment that would identify and measure important factors like overall performance, accuracy, and the effectiveness of the Drowsiness and Alcohol Detection System Using Arduino Uno. Through the application of quantitative approaches, the study aimed to extract accurate numerical data, which enabled a thorough examination of the system's functionality and advanced a more sophisticated comprehension of its operational effectiveness.

Data Gathering Procedure - The researchers, utilizing observational tools, closely examined and evaluated product performance. Observation, defined as the action of scrutinizing something for information, involves recording findings as evidence for honest and accurate results. A drowsiness and alcohol detection system was employed to test the product. Prior to the observation, the researchers gathered necessary information, enabling them to obtain insights through careful observation. In-person inspection of the product is crucial, and the researchers dedicate two days to the experiment to collect vital data and insights that contribute to accurate results and a deeper understanding. The experiment was conducted over two days in February and March 2024 at the researchers' home in Mabini Street at Barangay Pag-asa, San Jose, Occidental Mindoro. Notably, the study is only about developing and testing the detection system while taking into account potential environmental influences on its performance.

The experiment involved multiple sets of tests to record observations for both the drowsiness and alcohol detection systems. In the drowsiness detection system, accuracy and eye structure were assessed. For accuracy, researchers conducted 10 trials where they wore the device and attempted blinking or closing their eyes for more than three seconds to trigger the alarm, prompting an SMS to be sent to their designated contact. Similarly, for the assessment of eye structure, researchers repeated the process in 30 trials, examining two types of eye structures: round and narrow. The proper functioning of the alarm and SMS systems served as indicators for recording the data. In the alcohol detection system, consistency and alcohol amounts were evaluated. Three researchers consumed 10ml, 20ml, and 30ml of Soju Alcohol, each containing 14 percent alcohol, and had 10 trials respectively. They then breathed into the alcohol detection system, which would trigger an alarm and send an SMS to their contact person to test the device's consistency. Furthermore, for assessing alcohol amounts, similar to consistency, data was recorded based on the device's performance after 10 trials for each amount.

Research Process; Stage 1 Preparation and Gathering of Materials - To improve the effectiveness of a product, innovative materials are necessary. Researchers used the following resources and have opted for reliable and reasonably priced sources. The researchers placed an online order for the materials, keeping within a budget of around two thousand pesos (2,000 PHP). The materials used are Arduino Uno R3, MQ3 Module (alcohol detection), Infrared IR Proximity Sensor Module for Arduino, SIM800L V2 5V Wireless GSM GPRS Module, 9V battery, Eye Protection Glasses, Generic UNO Proto Shield Prototype Expansion Board and Globe Prepaid 5G SIM Card.

Stage 2: Building and Development of the Project - The project entailed integrating an Arduino Uno with various hardware components, including an alarm system and sensors for alcohol and drowsiness detection. This experimental study focused on crafting Arduino code and leveraging sensor libraries to process sensor data and manage the alarm system effectively. To monitor drowsiness, the researchers utilized an infrared sensor, which was programmed to detect a 3-second eye closure, indicating potential drowsiness, and to alert the user's emergency contact promptly. Additionally, the system was designed to activate an alert or trigger the buzzer function upon detecting alcohol in the user's system, thereby enhancing safety measures. Comprehensive documentation, comprising circuit diagrams, code explanations, and setup instructions, was meticulously prepared to facilitate seamless replication and deployment of the system. With these preparatory phases concluded, our system was poised for real-world application and evaluation. Hence, the product's construction lasted 2 weeks, after careful making. With these preparatory phases concluded, our system was poised for real-world application and evaluation.

Figure 1. Actual Product of Drowsiness and Alcohol Detection System using Arduino Uno

Stage 3: Experimental Stage, Observation and Data Recording - The effectiveness of the product was determined based on the performance of the individual components as well as the proper functionality of the entire device as it was intended. The eye-blinking sensor was evaluated based on its accuracy in determining the status of the eyelids - whether they are open or closed. The MQ3 sensor was evaluated on its accuracy in determining the alcohol content of the individual's breath and its consistency in detecting alcohol in the individual's breath. The entire device was checked to determine if it was functioning as properly intended and if the key parts were working in conjunction. To assess the advantages, effectiveness, and consistency of the drowsiness and alcohol detection system, researchers conducted a series of experimental trials. A blinking test was conducted to evaluate the safety of drivers and the general public in the drowsiness detection system. Utilizing the IR sensor, an alarm would be triggered if the driver closes their eyes for three or more seconds, and an SMS would be sent to the driver's designated contact person. Subsequently, to assess the alcohol detection system, the MQ3 module sensed the driver's breath. If any sign of alcohol was detected, an SMS would be transmitted to the driver's contact person.

Statistical Treatment of the Data - In this study, the researchers employed a weighted mean in determining the level of efficacy of the device as observed by the researchers. In addition, a t-test was used to assess the difference between the level of efficacy of drowsiness detection systems in terms of accuracy and eye structure. At the same time, the analysis of variance (ANOVA) was employed to assess the difference among the level of efficacy of the Alcohol Detection System in terms of the amount of alcohol detected in the driver's breath. The primary objective was to evaluate the system's performance in the following aspects: accuracy and eye structure for drowsiness detection, and the amount of alcohol for alcohol detection. In ANOVA analysis, the null hypothesis is that the means of all groups are equal, and the alternative hypothesis is that at least one group's mean is different from the others. The study aimed to address specific research questions, including differences in efficacy concerning drowsiness detection accuracy and eye structure, as well as the amount of alcohol detected in the driver's breath.

3. Results and Discussions

Table 1 contains the results of the experiment regarding the accuracy and eye structure of the Drowsiness Detection System. Recording of data was based upon if the device functioned correctly when the user closed their eyelid for more than 3 seconds, and the IR sensor detects this change. An infrared sensor is an electronic instrument which is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiation (Ajmera, 2018). Hence, a data score of “1” represents a correct function, while the data score “0” represents a malfunction. Throughout the 10 trials done, the Drowsiness Detection System scored a data score of “1” in each trial, giving it an average mean of 1 which also translates to a 100% efficacy rate in terms of accuracy for this experiment. These values correlate to similar results from the study of Singh et al. (2022) wherein their proposed drowsiness detection device had a 100% success rate under a similar environment to the experiment done. Moreover, in terms of the effect of eye structure on the recognition aspect of the Drowsiness Detection System. For this experiment, a narrow-eye structure was tested in a total of 30 trials, while a round-eye structure was also tested in a total of 30 trials. Similar to the first experiment, a data score of “1” represents a correct function, while a data score of “0” represents a malfunction. In the category of narrow-eye structure, the Drowsiness Detection System performed correctly in 28 out of the 30 trials, giving it a total average success mean of 0.93, this score fits in the range of 0.81 - 1.00, giving it a descriptive score of “very high level of efficacy”. While in the category of round-eye structure, it performed correctly in all 30 trials, giving it a total average success mean of 1.00, this perfect score gives it a descriptive score of “very high level of efficacy” as well.

Table 1

Mean Level of the efficacy of Drowsiness Detection System in terms of Accuracy and Eye Structure

Trials	Accuracy Results	NARROW–EYE STRUCTURE					ROUND–EYE STRUCTURE			
		NO.	TRIAL 1	TRIAL 2	TRIAL 3	Overall Mean	TRIAL 1	TRIAL 2	TRIAL 3	Overall Mean
1	1	1	1	1	1	1	1	1	1	1
2	1	2	1	1	1	1	1	1	1	1
3	1	3	1	1	1	1	1	1	1	1
4	1	4	1	1	1	1	1	1	1	1
5	1	5	1	1	1	1	1	1	1	1
6	1	6	1	0	1	0.66667	1	1	1	1
7	1	7	1	0	1	0.66667	1	1	1	1
8	1	8	1	1	1	1	1	1	1	1
9	1	9	1	1	1	1	1	1	1	1
10	1	10	1	1	1	1	1	1	1	1
Mean	1	Mean	1	0.8	1	0.93	1	1	1	1
D.I	Very High		Very High	Very High	Very High	Very High	Very High	Very High	Very High	Very High

Legend: (1 - functions properly & 0 - does not function properly/ malfunction)

Descriptive Interpretation (D.I): *0.01 - 0.20 - poor level of efficacy; 0.21 - 0.40 - low level of efficacy; 0.41 - 0.60 - moderate level of efficacy; 0.61 - 0.80 - high level of efficacy; 0.81 - 1.00 - very high level of efficacy*

The results of the experiment infer that there is a slight inconsistency in the performance of the Drowsiness Detection System in terms of the eye structure, however, this data indicates that no matter the eye shape the efficacy of the device remains at a high level. Similar results in the study of Verma et al. (2023), wherein their study utilized a webcam and data algorithms to detect drowsiness, their results coincide with the data recorded in the previous experiment as they claimed that eye shape and structure did not have a significant effect in their experiments.

Table 2

Mean Level of the efficacy of Alcohol Detection System in terms of Consistency and Amount of Alcohol

Trial	No. of Trials	No. of Successful Trials	Percentage of Successful Trial (Consistency)	No. of Trials	Amount of Alcohol (Average)	Interpretation
10ml	10	6	60%	10	0.6	High level
20ml	10	8	80%	10	0.8	Very High
30ml	10	10	100%	10	1	Very High
Total	30	24	80%	30	0.8	Very High

Legend: 0.01 - 0.20 - poor level of efficacy; 0.21 - 0.40 - low level of efficacy; 0.41 - 0.60 - moderate level of efficacy; 0.61 - 0.80 - high level of efficacy; 0.81 - 1.00 - very high level of efficacy

Table 2 contains the results of the experiment using 10 trials and the percentage of success for each category as well as the total mean percentage for the entire experiment. The categories of 10 ml, 20 ml, and 30 ml had a percentage of success of 60%, 80%, and 100% respectively as observed by the researchers. The overall consistency of the Alcohol Detection System in all 30 trials is measured at an 80% efficacy rate. The Alcohol Detection System utilizes a MQ3 alcohol sensor; this device is primarily made of SnO_2 otherwise known as tin(IV) oxide due to its high conductivity with gaseous materials which allows it to detect alcohol even in trace amounts (Das et al., 2020). 10 trials were conducted for each measurement of alcohol and was tested by three volunteered researchers in the group; 10ml, 20ml, and 30ml. In the first category, one of the researchers consumed 10 ml of alcohol, and their breath was tested over 10 trials. The data recorded shows that for the first 6 trials, the Alcohol Detection System functioned properly, while the 4 succeeding trials showed the Alcohol Detection System not functioning properly as it could no longer detect the presence of alcohol. This gives the test an average mean of 0.6 and a descriptive interpretation of a "moderate level of efficacy". In the second category, a volunteer consumed 20 ml of alcohol, and their breath was tested over 10 trials. The data recorded shows that for the first 8 trials, the Alcohol Detection System functioned properly, while the 2 succeeding trials showed the Alcohol Detection System not functioning properly. This gives the test an average mean of 0.8 and a descriptive interpretation of a "high level of efficacy". In the third category, a volunteer consumed 30 ml of alcohol, and their breath was tested over 10 trials. The data recorded shows that for all 10 trials, the Alcohol Detection System functioned properly. This gives the test an average mean of 1 and a descriptive interpretation of a "very high level of efficacy". Similarly, in the study of Trindade et al. (2014), they used a similar design of the Arduino Uno microcontroller and the MQ3 module for alcohol detection during their experiments, and it was found that there was a relative error of 15% in terms of the accuracy of the MQ3 sensor when detecting various concentrations of alcohol, thus they proved that Arduino Uno is effective in alcohol detection.

Table 3 displays the t-test results of Two-Sample Assuming Unequal Variances for Ho. The recorded p-value (0.167850656) of the two-tailed test is greater than the alpha level (0.05); therefore, for this experiment, the null hypothesis would be accepted. This means that there is no significant difference between the level of efficacy of the device and the eye structure of the user, whether it is narrow or round. Thus, 10 trials proved that there is a high level of efficacy in drowsiness detection. The findings are similar to the study conducted by Verma et al. (2023), wherein their study utilized a webcam and data algorithms to detect drowsiness; their results coincide with the data recorded in the previous experiment as they claimed that eye shape and structure did not have a significant effect in their experiments.

Table 3

t-Test: Two-Sample Assuming Unequal Variances for Ho1

	Variable 1 (narrow-eye structure)	***Variable 2 (round-eye structure)***
Mean	0.933333333	1
Variance	0.019753086	0
Observations	10	10
Hypothesized Mean Difference	0	
Df	9	
t Stat	-1.5	
P(T<=t) two-tail	0.167850656	
t Critical two-tail	2.262157163	

Legend: P-value ≤ 0.05 Significant; reject H_0.

Table 4

Analysis of Variance (ANOVA): Single Factor Results for Ho2

SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Column 1	10	14	1.4	0.266666667		
Column 2	10	12	1.2	0.177777778		
Column 3	10	10	1	0		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.8	2	0.4	2.7	0.08532	3.354131
Within Groups	4	27	0.148148148			
Total	4.8	29				

Legend: P-value ≤ 0.05 Significant; reject H_0.

Table 4 shows the results of a single-factor ANOVA test based on the data in the experiment. In ANOVA, the null hypothesis is that the means of all groups are equal, and the alternative hypothesis is that at least one group's mean is different from the others. The first data score to be analyzed is the F-value and the F-critical value; generally, a F-value lower than the F-critical value supports the conclusion of accepting the null hypothesis. In this experiment, the F-value (2.7) is lower than the F-critical value (3.354131). Therefore, this particular data score supports the acceptance of the null hypothesis. Furthermore, the p-value (0.08532) result is higher than the required alpha-level value (0.05), suggesting a similar conclusion. This means that there is no significant difference in efficacy based on the amount of alcohol. This conclusion is further supported by the study conducted by Trindade et al. (2014), wherein they used a similar design of the Arduino Uno microcontroller and the MQ3 module for alcohol detection; through their experiments, it was also concluded that the concentration of alcohol does not have a significant effect in the total accuracy of the device.

4. Conclusions

Based on the comprehensive analysis of the study's findings, the researcher draws the following conclusion: The drowsiness detection system demonstrated reliable performance in trials, detecting drowsiness across conditions and eye structure variations, indicating its potential for promoting driver safety and preventing accidents. The alcohol detection system demonstrated remarkable stability in experiments, consistently delivering reliable results despite variations in conditions, demonstrating its reliability and resilience for safety and incident prevention. The eye structure-based drowsiness detection system, which triggers a buzzer alarm for prolonged eye closures lasting 3 seconds, has shown potential for accident prevention and road safety enhancement. The alcohol detection system has demonstrated promising results in reliably detecting alcohol presence in breath samples, proving its efficacy in preventing accidents and enhancing road safety.

4.1 Recommendation

Drawing from an extensive analysis of the study's findings, the researcher puts forth the following recommendations for future researchers: It is recommended to enhance the sensitivity of the Drowsiness Detection System code to accommodate narrow eye structures, enabling positioning directly on glasses lenses for improved efficacy, to enhance detection accuracy, especially for small amounts, and ensure consistent buzzer durations for each detected alcohol level, the users may adjust the Alcohol Detection System code. Users may make trial errors and improve accuracy and efficacy thru adjusting and enhancing the Alcohol Detection System code to address. The parents or guardians may integrate a NEO-6M GPS module into the GSM module for conveying intoxication status and user location upon alcohol detection, recommending seamless operation within helmets without sensor adjustments, and consider employing smaller infrared sensors and a smaller variant of the Arduino Uno to lighten the weight of the device. Future researchers may further enhance the Drowsiness Detection System code's sensitivity to address inaccuracies observed with narrow eye structures.

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