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A Car Security System Based on Alerting Driver Drowsiness and Monitoring the State of the Vehicle

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Draft Version

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ABSTRACT

Accidents on the road are the primary cause of death, particularly among children and adolescents. Despite having fewer vehicles, low- and middle-income countries account for the preponderance of these fatalities. Consequently, a system that monitors vehicles and takes the necessary precautions to prevent collisions and fatalities is urgently required. This paper proposes a system of OpenCV image processing techniques to monitor the driver's eye movements in order to prevent accidents caused by behavioral and psychological changes while driving. The main processing unit (MPU) of the system we have developed consists of Raspberry Pi, Microcontroller, and sensors. Both on day and night time, it detects driver drowsiness and alerts them with a wristband. In low-light conditions, two infrared (IR) blasters and multiple light-dependent resistors (LDR) sensors were used to accurately detect driver fatigue. During an accident, the MPU's accident detection module will identify and send an SMS message to the vehicle owner with the vehicle's location and data. Eventually, the local police station, fire department, and other safety agencies will be able to take immediate action. The novel aspect of this study is the combination of image processing techniques and sensors that accurately monitor driver behaviour and identify fatigue. The accident detection module of the system is also distinct and can provide emergency services with vital information in the event of an accident.

CCS CONCEPTS

• **Hardware → Sensor applications and deployments.**

KEYWORDS

Accident Detection, Image Processing, Sensors, Driver Drowsiness Detection, Real-Time Monitoring, Emergency System, Driver Alert system

1 INTRODUCTION

Driver weariness ('drowning at the wheel') is a significant contributor to road accidents. Driving when drowsy is a typical occurrence. As dizziness impairs vision. Thus, in order to address this issue, we will create a system device. For road safety technologies, this research will aid in the reduction of accidents caused by driver inattention. It is primarily for the protection of those who travel and drive. A driver's error can result in significant property damage or physical injuries, as well as fatalities and economic losses.

The motivation for developing such a device stem from a variety of factors, including concern for human safety and economic loss. Numerous factors, most notably human error, contribute to traffic accidents.

In the context of Bangladesh, if we already know the problem and its solution then why not. The only thing we face in our day-to-day life is problems and the surprising thing is everyone only talks about the problem not the solution nor how they can solve it. So, we pulled of some of the people who wants to focus on the solution and wants to work hard for it. We believe in lives, no more losing precious people from our life.

Before getting into this research our team talked to several Driver, Vehicle owners, Passengers also monitored our traffic system for couple of weeks and some of their thoughts were like When they feel tired driving continuously, they start Yawning and their eyes gets smaller that time they think they are okay and can manage the situation but sometimes while thinking about that they fall asleep and what supposed to happened happens. And some other says people of developed countries uses Energy Drinks which contains many bio chemicals along with the caffeine which helps to reduce tiredness and weakness but in Bangladesh energy drinks are expensive and not affordable to everyone so most of the drives smokes cigarettes to stay wake which in some point has no connection to reduce tiredness or weakness and as a long-time smoker they get too many after effects like cancer, lungs disorder, stroke etc. Some are concerns about their vehicle security if it gets stolen others are concerned about what if accident occurs what are the necessary steps can be taken immediately to reduce injuries. Most of the people living in the city only concerns about how the public transport system can be improved.

Automobile accidents are most often caused by driver fatigue. According to the American Psychological Association, drowsiness is a state of decreased alertness often accompanied by performance and physiological changes impairing alertness. According to the National Highway Traffic Safety Administration (NHTSA), in the United States, 100000 automobile accidents occur each year, with fatigue playing a vital role in a considerable percentage of them. Over $12.5 billion has been spent on these occurrences, which have resulted in 1550 deaths and 71,000 injuries [16]. According to the United States National Sleep Foundation, 54% of young adults admit to driving when fatigued, and 28% of those drivers admit to falling asleep entirely while driving [3]. According to the German Road Safety Council (DVR) (Deutsche Verkeh Rswacht), short fatigue accounts for 25% of fatal automotive incidents in highway traffic [7].

Driver fatigue [4] [13] [10] is a major contributor to a significant number of traffic accidents. Between January and December 2021, at least 6,284 people died and 7,468 others were injured in traffic accidents, according to the Bangladesh Road Safety Foundation's (RSF) annual report, compared to 5,431 fatalities and 7,379 injuries in traffic incidents in 2020. The most challenging thing in developing accident prevention systems is building technology capable of detecting or preventing tiredness. Because sleepiness poses a danger on the road, it is vital to devise strategies to mitigate its repercussions. Motorist negligence may result from a drivings lack of awareness and driver fatigue and distraction. Consequently, we investigated tiredness in professional drivers using image processing and observed their eye movements. We achieved this because it is crucial to identify driver tiredness without annoyance effectively, and since nearly no real-time solutions for this purpose have been described in earlier research. Also, the research includes Driver alert systems, Vehicle accident detection, Emergency services, Vehicle tracking systems.

1.1 Problem Statement

The problem is the high number of road accidents in low- and middle-income countries, particularly among children and adolescents, caused by driver fatigue and behavioural and psychological changes while driving. The role of driver fatigue as a cause of road accidents is frequently underappreciated and underreported, with its impact being primarily attributed to prolonged and irregular working hours rather than the length of time spent driving [20].

The particular subtasks that involve resolving the research issue are:

- Using OpenCV image processing techniques to create a system that accurately tracks the eye movements of drivers.
- Detecting driver fatigue and alerting the driver via a wristband by integrating sensors and a main processing unit (MPU) comprised of Raspberry Pi, Microcontroller, and sensors.
- Developing an accident detection module capable of identifying the vehicle involved in an accident and sending an SMS message with the vehicle's location and data to the vehicle owner.

1.2 Contribution of this work

The Driver Drowsiness Alert, Vehicle Accident Detection, and Safety System is built with image processing Open-CV, sensors, and MPU. In addition, the vehicle must be equipped with properly mounted Smoke senor(SS), Gas sensor(GS), Gyroscope sensor (GY), and Water detect sensor (WDS) for detecting accidents and the severity of collisions. When an driver drowsiness is detected, the motorist is alerted by a vibration-producing wristband and an emergency number is notified (Like as Bangladesh perspective 999). Consider a scenario in which a car accident is caused by drowsiness. In such a case, the information gathered by the sensors and alert message transmitted via GSM communication to the nearest police station, fire department,and ambulance are longitudinal and altitude coordinates of the incident's location.

The rest of this paper organized the following manner. In section 2, The Related Works in included, and in section 3, we give our proposed system to the research problem.In section 5, we reported the result, and in section 6, we came to a conclusion and discussed future study possibilities.

2 RELATED WORKS

Lopar, M et al. [11] discussed evaluating several approaches and algorithms for face and eye identification to determine which ones are suitable for use in a system for tracking driver fatigue.Traditional Viola-Jones face detector produced the best results. Kumar, K.P et al. [9] illustrated the use of visual processing to identify a driver's tiredness using MATLAB. They concluded that around one-fourth of all catastrophic road accidents occur due to drivers' tiredness during a break, demonstrating that drowsiness causes more accidents than drunk driving. A driver drowsiness detection system was developed by Seemar, P et al. [19] based on the image analysis and computer vision methods. The authors found that the system was ineffective system or lack of light, causing errors due to non-detection of eyes. However, the system performed impeccably in normal light, achieving up to 94 percent accuracy.

Poursadeghiyan, M et al.[14] recommended incorporating image processing techniques into the design of their proposed sleepiness detection system. Using the Violla-Jones algorithm, facial emotions and eye position were identified. The system's detection accuracy was 93%. A complete IoT-based accident detection system was developed by Alvi, U et al.[1]. Crash prediction strategies based on cellphones, vehicle ad-hoc networks, GPS/GSM-based systems, and machine learning algorithms were incorporated into their system. A vulnerability analysis of the emergency response system was developed by Rustamov, A et al.[17] based on navigational units in the event of a vehicle accident. In this system, to accurately determine spatial coordinates, the navigator must receive data from at least four satellites. A voice signal and facial image processing system was developed by Espinoza-Cuadros, F et al.[5] to investigate the possibility of diagnosing sleep apnea. Images and voice processing are used to estimate AHI in 285 Spanish males suspected of having OSA who were sent to the sleep disorders center for evaluation.

To ensure the safety of fully autonomous vehicles, multidisciplinary processes are necessary, ranging from hardware fault tolerance to resilient machine learning algorithms discussed by Koopman, P et al.[8]. Sahayadhas, A et al.[18] presented an overview of detecting driver drowsiness using sensors. They determined driver drowsiness using vehicle-based, behavioral, and physiological measures. A method for detecting vehicle accidents was proposed by Matthews, V. O. et al.[12] implemented a system to detect accidents. Babu, T. et al. [2] developed an alert system for sleep detection in automobiles. Their developed system was used on lorries, trucks, and other night-time vehicles. Hu, S. et al.[6] proposed a solution for driver drowsiness detection with eyelid-related parameters using support vector machine. The contribution of this research is to forecast sleepiness using a support vector machine (SVM) where eyelid-related metrics are taken from EOG data gathered in an EU project sensation driving simulator.

3 PROPOSED SYSTEM

There has been an alarming rise in traffic accidents in Bangladesh over the past few years, to the point that it has become a national concern. Each day, around eight individuals are killed in automobile accidents. Actual mortality rates are very certain to be far higher. Our suggested system includes tracking and accident prevention features. More importantly, the automatic emergency steps-taking feature. It is not only used to track the locations of stolen vehicles but also incorporates security measures that allow us to take Emergency actions within minutes using GPS and GSM technology. One of the most frequent causes of road accidents is "driver sleepiness." In our proposal, we will propose several enhancements that will assist in preventing many road accidents and guarantees the safety of the passengers and vehicles, and our emergency action feature will significantly reduce casualties.

The system continuously monitors the human face for drowsiness detection, and in parallel accident detection system monitors vehicle sensors data. If the device detects driver drowsiness initially, it will generate an alert within the device and to the wristband watch. The device has a day and night vision feature that constantly monitors light levels and in low light, it turns on the IR Bluster for the Raspberry Pi to monitor the driver's face continuously. If the vehicle is involved in an accident, the accident detection system detects it and immediately sends an alert text to the driver's wristband, instructing them to turn off the alert if it is a false alert. In case of an emergency when the driver is not able to turn off the alert, the emergency system initiates emergency phase 2, in which vehicle data is sent to the vehicle owners or emergency contacts. By that, they will be able to take the necessary steps as soon as possible to minimize casualties.

The flow chart of the proposed solution is illustrated in figure 01. The presence of the conditions explains how the system operates. The Accident detection system, Raspberry PI, GSM module, GPS module, and wristband receiving and transmitting data to the main processing unit. If the Raspberry PI detects the driver's drowsiness or sleep, Arduino receives a signal through the Arduino Raspberry PI I2C connection. The accident detection system is a separate system from the MPU and connected to the MPU using I2C that monitors several sensors installed in the vehicle to detect any type of accident scenario. The MPU (Main Processing Unit) gets continuous location data from the Satellite GPS module and also reads text messages received by the GSM module. Any kind of alert first gets passed to the wristband to confirm the alert's authenticity. In a different situation, The MPU is responsible for taking appropriate actions depending on the scenario.

3.1 Drowsiness detection

In the main device, there will be two cameras as shown in figure 02, one facing the driver for drowsiness detection and another one is the rear camera which view will be displayed on the screen, and for that, the device will also work as a rear camera view. An image processing technique is being applied to identify drivers' drowsiness. Through the driver-facing camera, the device will continuously monitor the driver's eyes. It will alert the driver (both on display and wristband) if it detects the first signs of tiredness.

Real-time image processing with computer vision algorithms is implemented using OpenCV. When face characteristics are effectively identified, the following stage, such as the identification of sleepy drivers' eyes, may be concentrated on using facial landmark prediction algorithms.In order to convert this picture frame format to grayscale, it uses six coordinates to trace the identified eye regions, as illustrated in Figure 03. Calculating EAR, which calculates the distance between two points, is now mandatory. Equation shows the vertical and horizontal eye landmarks using the Euclidean distance (ED) approach (1). The calculation is as follows:

$$iED(Y_i - X_i) = \sqrt{\sum_{n=1}^{n} (Y_i - X_i)^2 (1)} \quad (1)$$

The equation(1) represents ED between two points in n-dimensional space, where xi and yi are the coordinates of the two points.Yi in (1) represents the dependent variable's actual values in a given dataset. The dependent variable is the variable for which predictions or estimates are generated using independent variables. The Yi coordinates represent the individual data points for the dependent variable in the dataset.The term (Yi - Xi) represents the difference between the i-th dimension coordinates of the two points. The equation(1) computes the square of each dimension's difference and adds the squares together. Finally, the distance between the two points is calculated by taking the square root of the sum.

Six landmark coordinates are shown in Figure 03 (X1, X2, X3, X4, X5, and X6) (b). The averaged EAR values of the two eyes are recorded during synchronized eye movements. The EAR threshold value is constant when both eyes are open, but values fluctuate erratically when an eye blinks. The driver's eyes are open if the EAR threshold range is higher than 0.25. Input images can be used to identify driver drowsiness if the threshold value drops below 0.25. The system will notify the driver by showing a sleepiness alert message on the driver's display and wristband if the threshold value is more than 0.25 and tiredness is detected three times in a row within five minutes. If the drowsiness gets detected thrice

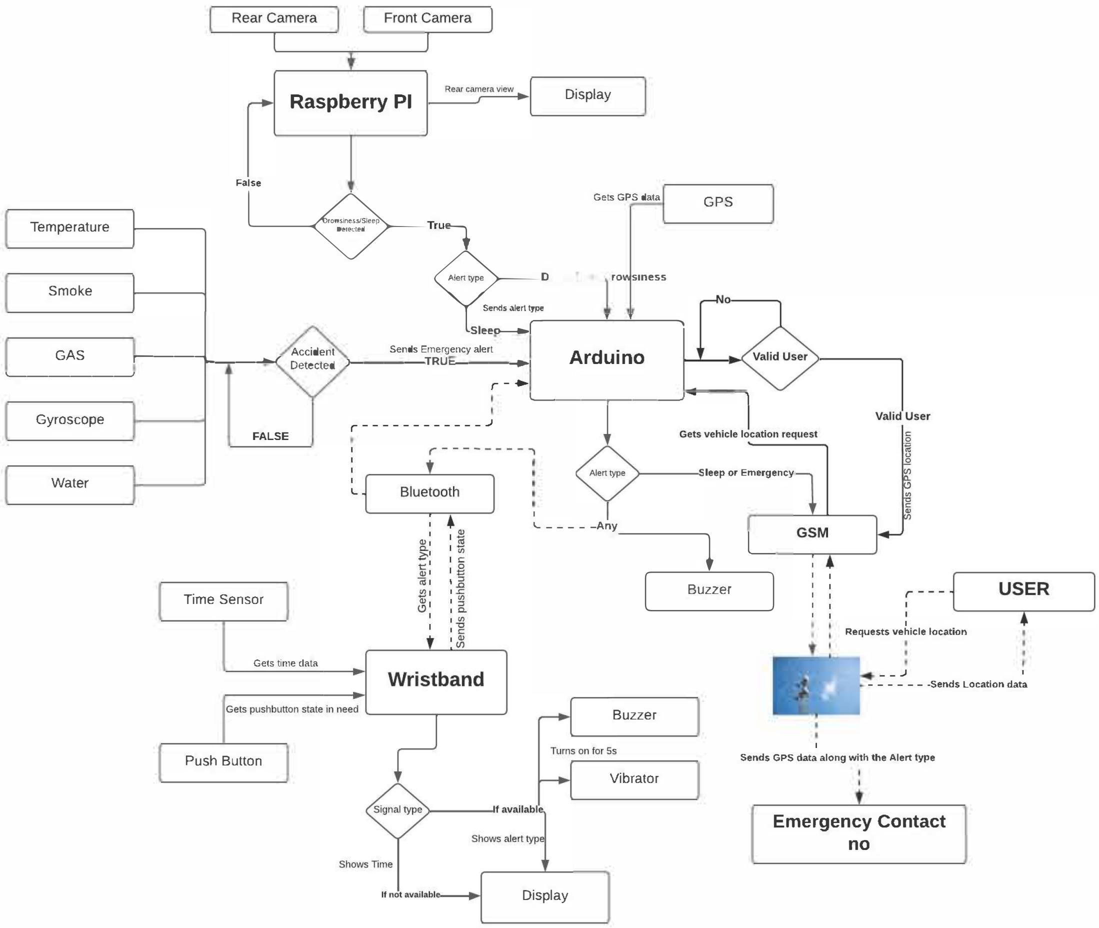

Figure 1: Flow diagram of the full proposed system

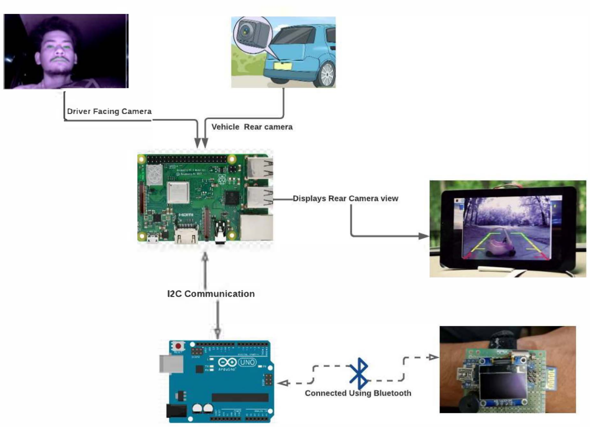

Figure 2: Block Diagram of the Drowsiness detection

continuously within 5 minutes, the system will alert the driver by showing a drowsiness alert text on display and on his/her wristband. Then Emergency Phase 1 will be initiated, where a concerned

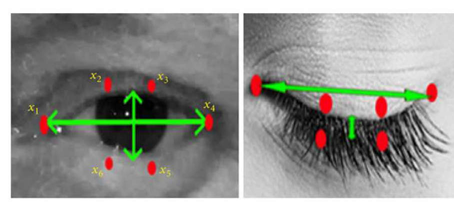

Figure 3: Eye landmarks in 6 coordinates of opening and closing eye.

person will be notified of the car's current location and parameters. The potential solutions for drowsiness detection are illustrated in figure 02.

3.2 Alert system

All notifications will be shown on a wristband-based watch. The system includes a buzzer, a LED display, a vibrating motor, and a switch. When an alert or emergency is activated, the alert will be displayed on the wristband display, and the wristband's vibration and the buzzer will be activated simultaneously. If the signal is an emergency, a 10-second countdown will appear on the wristband display. If the driver does not press the wristband's switch within the given time, the emergency function will be activated, where the wristband watch will display the confirmation text. In figure 04, our developed solution for a wristband alert system is presented.

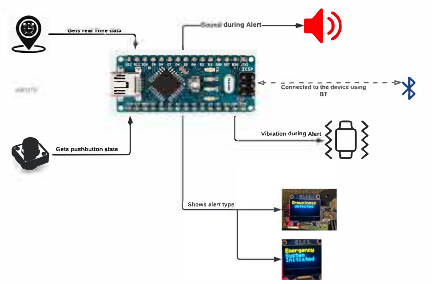

Figure 4: Block Diagram of the wristband alert system

3.3 Location tracking

This feature allows the system to track the vehicle's GPS position and report it to authorized people. If the driver repeatedly tries to sleep, the vehicle owner or emergency contacts will receive the vehicle's current location as well as the vehicle's status. Also, if any accident occurs, vehicle data will be sent to the owner/emergency contact as well to take the necessary actions as soon as possible. This function also allows car owners to track their vehicle's location using GSM network service without any emergency situation. If the car is stolen or misplaced, this function comes in handy. The position may be traced by sending a text message to the vehicle's GSM number. The user must include keywords such as user id and password in the text. The system will automatically provide car location data in a return text if the user id and password are valid. This feature allows vehicle owners monitoring his/her vehicle in

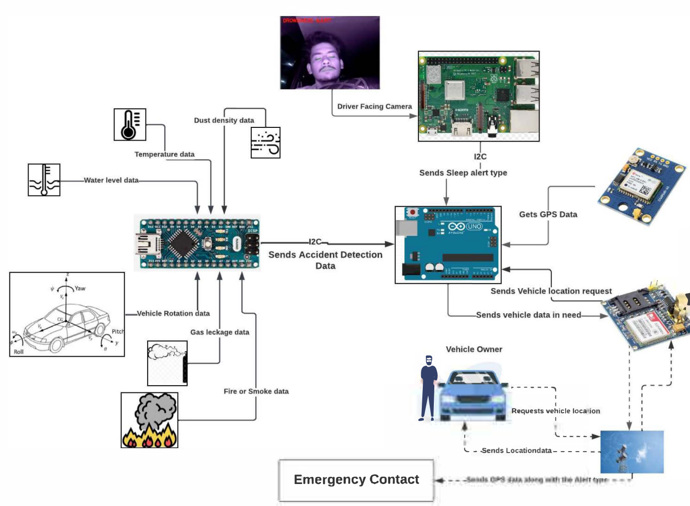

Figure 5: Block Diagram of the Drowsiness detection, Location tracking, and accidents detection

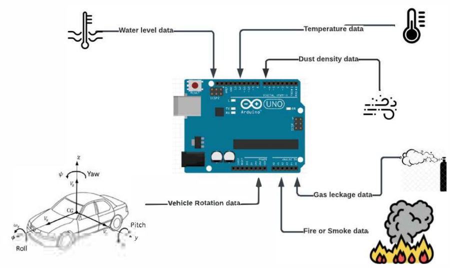

Figure 6: Block Diagram of the detection of accidents

real-time. The elements of the suggested approach for location tracking are shown in figure 05.

3.4 Detection of accidents

This region is self-sufficient in specific ways. A gyroscope, a temperature, a gas, and a water sensor are used to predict different accident situations, such as a car catching fire, colliding with something, falling into the water, flipping on the road, or having a gas leak. Every sensor has a threshold parameter. While the current data exceeds the threshold parameters, the system will classify it as an accident and send a signal to the main system, which will be forwarded to the wristband for the driver's approval (if it's a false alarm or not) before sending vehicle data to the emergency. The proposed solution for the detection of accidents system is shown in the figure in figure 06.

4 RESULT AND ANALYSIS

Numerous crucial components are included in the recommended road safety system. The prototype was developed by combining these features. This section discusses the impact of these features.

4.1 Result of The Drowsiness Detection System

An embedded system and a night vision camera module are used in this system to determine whether or not the driver is fatigued. Whenever the driver's eye is closed for more than three seconds, it is determined that the car driver is sleepy. When insufficient light is inside the car, the module turns on the night vision mode. A night vision camera captures photos with the help of an invisible flashlight that is hidden from view.

There are two IR flashlights and three LDR sensors with the camera module figure 07. LDR sensors detect the low light condition and turn on the IR blaster. With the help of an additional Infrared Ray (IR) flashlight, the camera gets a perfect image with enough light to detect the driver's face and expressions. Human eyes are not sensitive to infrared light, so it does not cause any problems to the driver driving.

While the driver was being tested day and night, as seen in Figure 08, the raspberry pi kept a view of the situation. Because the raspberry pi was fitted with a night vision camera module, it was necessary to employ an invisible light to monitor the driver's condition in a dark environment. Where RPi detected face landmarks such as eye position from where drowsiness has been calculated.

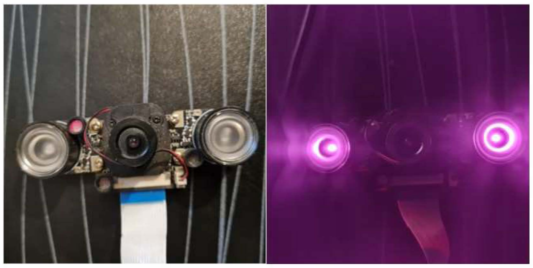

Figure 7: Camera Module with IR Bluster

Figure 8: RPI detected Face Landmark

Figure 9: RPI Detecting Driver's Drowsiness

Because the driver did not close his eyes throughout that time, the system was unable to detect any signs of fatigue in him.

In the dark atmosphere, the Raspberry Pi recognized the driver's drowsiness and alerted the driver. As already confirmed, the camera utilized an IR light to watch the driver while driving in total black. The system detected drowsiness if the driver closed his eyes for three consecutive seconds, which was programmed into the system. Consequently, the Raspberry Pi could identify the model's tiredness and alert the user. The system identified the driver's fatigue, shown in figure 09, because his eyes closed for three seconds while driving.

As illustrated in Fig.10, the driver's drowsiness was detected more than three times consecutively. Thus, the Raspberry Pi generated an emergency signal and sent it to Arduino, which performed previously stated functions. Because of not getting any response from the wristband the location of the vehicle was sent to the appropriate person along with the emergency message.

4.2 Result analysis of the Alert system

The warning system can be engaged twice. When the Raspberry Pi detects driver drowsiness or a potential accident, it alerts the driver. A buzzer and vibrator bracelet alerts the motorist of the system's presence. The wristband is connected to the MPU (Main Processing Unit) using Bluetooth to receive alerts. When an alarm message is received, it is displayed on the wristband to alert the user. It notifies the car's owner of any accidents. This device prevents drivers from dozing off. Figure 11 shows the wristband's drowsiness alarm. Arduino transmits the message, which the wristband receives

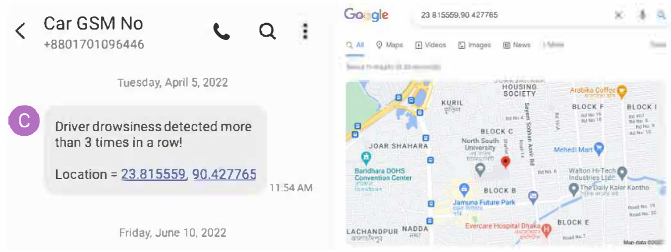

Figure 10: Main processing unit sends GPS coordinates

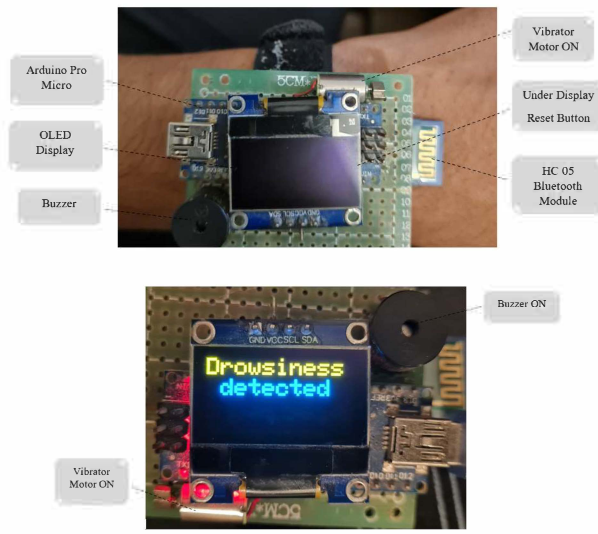

Figure 11: Drowsiness Alert Message Displayed on The Wristband's Display

through Bluetooth. The bracelet sounds and vibrates for 5 seconds to wake up the driver.

4.3 Detection of Accidents

Combining sensors creates this system. The temperature sensor detects a temperature rise. The gas and smoke sensor detect gas and smoke. A water level sensor detects water within the vehicle, and a Gyroscope sensor detects collisions with other vehicles or objects. If any sensor results cross a specified value, the system detects and calculates the accident likelihood.

Temperature, smoke, water, and system rotational movement in X, Y, and Z-axis data are shown as expected in Figure 11. Also, in Figure 12, The system detected the vehicle's accident probability when the water level sensor submerged and crossed the predefined value. As the wristband warning wasn't marked as false, the main processing unit sent vehicle position data and sensor data to the owner and emergency contact number.

The smoke sensor was used to detect the smoke. As soon as the smoke level exceeded the predefined value, the system classified it as an accident and then sent the vehicle data with the vehicle's location data to the emergency and owner's contact using the GSM

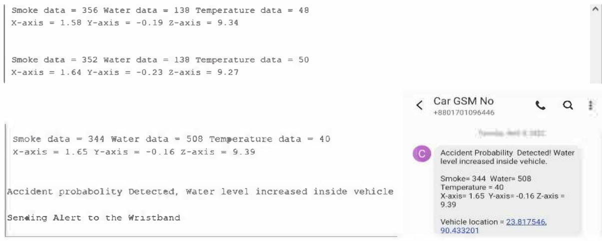

Figure 12: Normal Condition and Accident Probability Detected

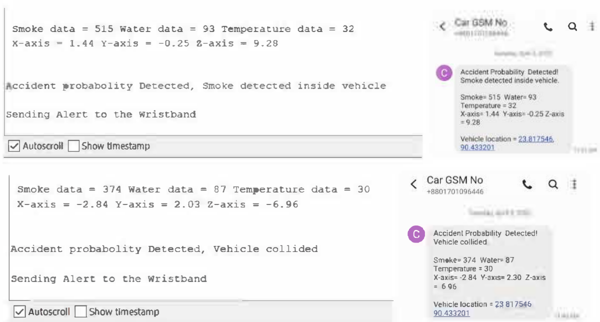

Figure 13: Accident Probability Detected, Smoke detected inside vehicle and Vehicle Collided

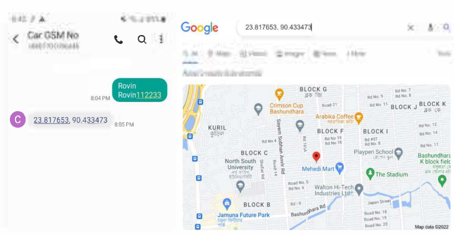

Figure 14: Vehicle Location Tracking

network, as shown in Figure 13. The gyroscope sensor monitors vehicle position in the X, Y, and Z axes; thus, if an accident occurs and the vehicle position is abnormal, the system will identify it. The system will detect a fire when the temperature and smoke sensor are high enough.

4.4 Location Tracking

In terms of vehicle security, location-tracking technology is beneficial. When the car owner wants to know where his vehicle is, he enters his username and security key and sends a text message to the vehicle's GSM number. When the text is received by the car, the MPU (main processing unit) will read the text message and retrieve the user name and his security key. If the user name and security key match, the device will transmit its location data in a return text.

As we can see, the reply text includes the latitude and longitude of the vehicle's present location. This function allows the car owner to remotely locate his vehicle if it is stolen and also allows the owner to monitor his vehicle while it is in operation.

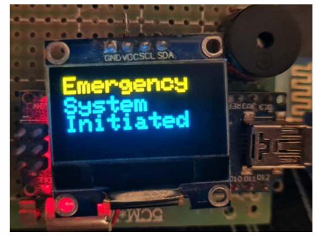

Figure 15: Emergency initiated Alert Message Displayed on The Wristband's Display

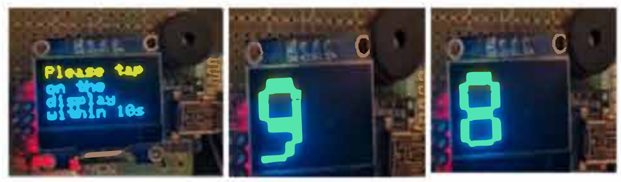

Figure 16: 10 Sec Countdown Alert Message Displayed on The Wristband's Display

4.5 Emergency System

The emergency system is activated in two ways. When the driver's drowsiness is detected three times, and when the vehicle's accident probability is detected. This system uses an Arduino Uno, a buzzer, GPS, and GSM. When the Raspberry Pi sends an emergency signal to the Arduino, it beeps for five seconds and sends the alert data to the wristband. Using GSM and GPS technology, it will also send an emergency alert message to emergency contacts containing the vehicle's location if the driver does not turn off the emergency alert within 10s. Furthermore, the emergency alert message and the countdown will be shown on the wristband's display.

As in Figure 15, Emergency System Initiated text is shown in the wristband display. In the meantime vibrating motor and alert sound also turns on to alert the driver.

In Figure 16, we can see the 10s countdown started. If the driver does not tap on the display within 10s, the wristband will send no response signal to the MPU. Underneath the display, there is a restart button. If the driver taps on display, the alert system will restart, and it won't send any response to the MPU.

In Figure 17, we can also see that vehicle data has been sent to the vehicle owner and the emergency contact for further investigation. This happens because the driver didn't tap on the display within the given time when the alert and countdown were shown. That is why the system activated the emergency system and transmitted the vehicle's location and other credentials to the emergency contact.

5 FUTURE WORK AND CONCLUSION

In this research project, we tried to reduce the number of road accidents and casualties by solving real problems. We created a system that detects and monitors drivers' drowsiness and the probability