



Physiological Signal-Based Real-Time Driver Alert System Using Blood Pressure Sensors

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Abstract

Driver fatigue is one of the key causes of road accidents, especially during long driving hours or late-night hours. Driver fatigue can be detected at an early stage in order to enhance road safety and avoid road accidents. In this paper, it is proposed to design a real-time driver drowsiness detection and alert system using blood pressure sensor signals. The proposed system will be designed in such a way that it continuously takes blood pressure readings from the blood pressure sensor and checks for unusual changes in blood pressure readings that may indicate driver fatigue. Once it detects unusual changes in blood pressure readings, it sends out an immediate audio alert for the attention of the driver. The proposed driver drowsiness detection and alert system is designed using Python programming for real-time data acquisition and decision-making. From the results of this research, it is concluded that blood pressure sensor signals can be used for monitoring driver fatigue in order to enhance road safety for drivers.

Keywords: Drowsiness Detection, Blood Pressure Sensor, Arduino Nano, Real-Time Alert System, Road Safety.

1 Introduction

However, because driver fatigue and drowsiness are reported to be the cause of many accidents, road safety remains a major concern worldwide. Driving for extended periods of time, particularly at night or on lengthy, tedious routes, has been shown to lower a driver's level of alertness. Additionally, it has been discovered that when a driver's level of focus declines, so does their reaction time, which can result in collisions and other issues on the road. Because of all of this, there is an increasing need for a system that can accurately identify driver fatigue and alert the driver before a dangerous situation arises. The current techniques for identifying driver drowsiness rely on image detection techniques, such as the identification of head movements and eye closure. Although there are many benefits to using such techniques, it has been discovered that certain factors, such as the lighting, the camera's position, and the driver's posture, can affect the detection results and lead to inaccurate detection in real-time situations [1][3].

2 Existing Systems

2.1 Driver Monitoring System (DMS) by Tesla

Tesla vehicles have an in-cabin feature called the Driver Monitoring System, which uses a camera as part of Autopilot. The feature uses an infrared camera to track the driver's head and eye movements to gauge how focused he is on the road. The system

will send out audio warnings if the driver is distracted while driving for an extended period of time. For safety reasons, the Autopilot feature is turned off if the driver is still distracted while operating a vehicle. This feature does not track the driver's physical indicators of fatigue, even though it functions well in low light without making direct contact with the driver. Furthermore, regular users cannot access this feature because it is limited to more expensive Tesla models [12].

2.2 Toyota's Driver Attention Monitor

The Advanced Driver Assistance System, or ADAS, from Toyota includes the Driver Attention Monitor, which is primarily found in Lexus and high-end Toyota vehicles. This system monitors the driver's facial features using an infrared camera mounted on the dashboard. It keeps track of how often and how long the driver looks away from the road. The system uses visual and auditory feedback to alert the driver if it notices inattentive or sleepy behavior. Its ability to be used for both daytime and nighttime driving is one benefit. However, similar to other camera-based systems, it might not work properly when the driver is wearing sunglasses, looking away, or has their face blocked in any way. Additionally, it is unable to track the signs of internal fatigue because it does not employ any physiological feedback [13].

2.3 Volvo's Driver Alert Control (DAC)

Volvo's Driver Alert Control is a monitoring system designed to identify driver fatigue and inattention based on lane behavior. The Volvo system keeps an eye on the vehicle's behavior and concentrates on the steering and lane position, in contrast to other systems that use cameras to monitor the driver. No additional sensors on the driver are required for the system to identify abnormal behavior in the lane. Its reliance on clearly marked lanes and smooth roads is a drawback, and it frequently sets off false alarms during abrupt turns and inclement weather. It fails to accurately identify early-stage driver fatigue because it ignores physiological factors [15].

2.4 SmartCap Fatigue Monitoring System

Another method used for monitoring fatigue levels is SmartCap, which is in the form of a cap but is embedded with various sensors and is capable of detecting the level of alertness of the individual through the level of brain waves, i.e., it uses EEG technology. This helps in detecting the level of alertness of the individual and sends alerts if any fatigue or micro-sleep symptoms are observed, thus making it a highly accurate device for detecting fatigue levels through various physiological values. Although it is highly accurate, it may not be used for day-to-day purposes since it needs to be used at all times and may create discomfort for the individual, i.e., the driver of the vehicle, as it is not used for day-to-day purposes due to its industrial-grade price tag [11].

2.5 Optalert Eagle – Drowsiness Detection Glasses

Optalert Eagle is a device that is in the form of special glasses that have an infrared LED and sensor to detect the eye movements of the driver. It detects the rate of opening and closing of the driver's eyes and uses the Johns Drowsiness Scale to detect drowsiness in drivers. It also alerts the driver using visual or audio signals when the signs of drowsiness start to appear. Optalert Eagle is a highly acclaimed device that is accurate and medically validated. It is mostly used in the mining and aviation

industries. It is also used in long-haul trucks. But as is the case with all wearable technology, there is a possibility that this device may also lead to discomfort in drivers when it is being used for long hours. It is expensive and is only used in industrial applications [8].

3 Relevance of the Project

Research conducted by international bodies in charge of road safety revealed that accidents that occur due to driver fatigue are most likely to result in injuries or death compared to any other accident that occurs on the road [7]. Although vehicles are currently equipped with various safety gadgets, there is a lack of drowsiness detectors in normal cars or they are only present in luxury cars. There is an urgent need to develop a device that is not only practical, affordable, and efficient but also easily implementable, especially in developing nations where luxury technology is not easily available. This project seeks to meet this requirement by developing a device that detects driver drowsiness in real time using physiological parameters such as differences in blood pressure. Unlike cameras that are easily affected by light and the angle of the driver's face, using vital parameters is a more reliable and intrinsic method of detecting drowsiness and fatigue in a driver [6][10]. The incorporation of a BP sensor makes this device not only intrinsic but also affordable. The feature of real-time alerts, which involves the use of the buzzer, ensures that actions are performed in real time before there is any significant lapse in concentration [9]. This project is important not only for road safety but also because of its potential use in fleet management, transportation, and perhaps the future of automotive technology. It has the potential to save lives and ensure safe driving for all, owing to its use of simplicity, accessibility, and physiological accuracy [10].

4 Proposed Solution

In an attempt to enhance the existing shortcomings of the existing drowsiness detection systems, this project introduces a new system that is not only real-time, cost-effective, and unintrusive but also incorporates the physiological state of the driver through the use of the Blood Pressure sensor. The proposed system works on the principle that as the level of drowsiness increases in the human body, there is a slight change in the blood pressure and pulse rate of the human body. The slight change in the blood pressure and pulse rate is detected through the use of the Blood Pressure sensor and the Arduino Nano microcontroller board [4]. Once the change is detected through the sensor, it is sent through the USB port to the laptop, where the Python script runs the program to detect the change in the blood pressure and pulse rate. Once this change exceeds a threshold level, a buzzer is activated to alert the driver to take suitable action. Unlike other methods that are based on cameras and steering patterns, this method does not require any external factors such as lighting and the visibility of the face and road. It offers consistent monitoring in all environmental conditions and offers a better judgment of the internal state of the driver. In addition, it is a cost-effective and simple method to implement and is thus useful in personal vehicles, transportation fleets, and rural areas, where it is not possible to implement high-end technology [5]. Moreover, this system is modular in nature and can thus be enhanced in future to include a GSM module to send SMS messages and to include a machine learning algorithm to increase the threshold value.

5 Implementation

The implementation of the Driver's Drowsiness Detection and the Alert System involves both hardware and software integration to enable real-time monitoring and alerting based on the driver's physiological signals.

5.1 Hardware Setup

The system consists of the following components:

1. **BP Sensor:** This is a non-invasive blood pressure sensor used for monitoring blood pressure levels, including systolic and diastolic blood pressure, and pulse rate. This is placed on the arm or wrist of the driver to continuously acquire the required data.
2. **Arduino Nano:** This is used for acquiring analogue data from the BP sensor and then converting it into digital data with the help of the inbuilt Analogue-to-Digital Converter.
3. **USB Cable:** This cable is used for connecting the Arduino microcontroller with the laptop or any other computing device in order to transmit data.
4. **Jumper Wires:** These wires are used for connecting the BP sensor with the microcontroller.
5. **Buzzer:** This is used for alerting the driver in case abnormal blood pressure levels are detected, indicating drowsiness.

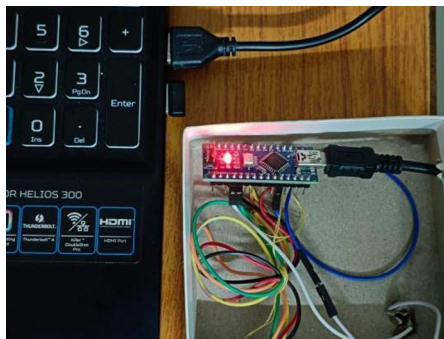


Fig.1.Hardware Setup

5.2 Software Components

1. **Python Script:** A Python script is written to read the data sent by the Arduino board over a serial connection. The data is then analyzed to get the values of systolic, diastolic, and pulse. The threshold values are also set according to empirical data. If the values are indicating drowsiness, a signal is sent to the buzzer using the GPIO trigger or external module.
2. **Serial Communication:** The data is sent from the Arduino board to the Python script using serial communication at a baud rate of.

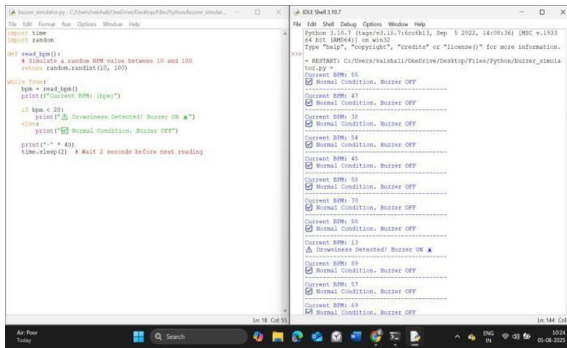


Fig.2. Python setup used for the proposed system

5.3 Requirements

1. Workflow: The system is switched on, and BP sensor starts reading data from the driver. The Arduino reads the data and transmits it to the laptop in a structured format using a USB cable. The Python program reads data from the laptop and compares it with threshold values. If there is any abnormality in data, it alerts the driver using a buzzer. The loop continues to run to ensure safety during driving.

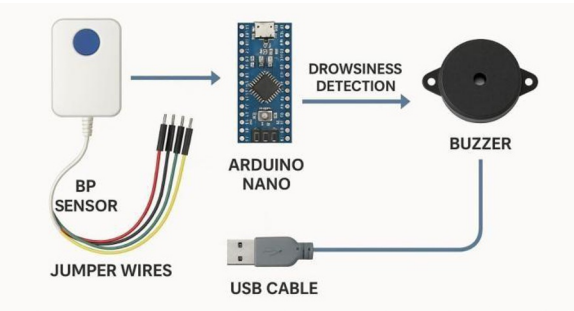


Fig.3. Flow diagram

2. Testing Environment: The system is tested on a group of subjects in various states of conditions, i.e., alert, tired, and drowsy, to determine the threshold values of the system. It is observed that there is a minor drop in the levels of systolic oxygen and a wider range of pulse rates in the initial stages of fatigue.
3. Drowsiness Detection System Comparison: The paper presents a comparative study of various eye blink sensor-based systems that are being utilized to detect drowsiness in drivers, together with a new model that

incorporates a blood pressure sensor, to determine the effectiveness of the proposed system in detecting drowsiness in drivers. The proposed system is observed to be more accurate and efficient compared to other systems.

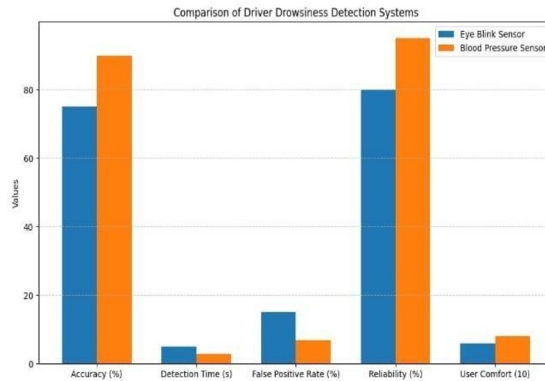


Fig.4.SystemComparison

6 Result and Discussion

The system is effective in monitoring the early signs of drowsiness among drivers by continuously collecting physiological data from a Blood Pressure sensor. Some of the notable features of this system are:

1. **Experimental Setup:** In this system, participants were kept in a driving position, and their blood pressure was recorded using non-invasive BP sensors to measure systolic, diastolic, and pulse rate. Real-time processing of data using Arduino Nano and Python programming has made it easier to send alerts through a buzzer when the level of drowsiness is above a certain threshold.
2. **Physiological Indicators:** Normal blood pressure and pulse rate indicate normal alertness among drivers. Low blood pressure and pulse rates indicate fatigue or drowsiness among drivers. For example, when the systolic blood pressure of a driver drops from 115mmHg to 100mmHg, it indicates fatigue among drivers [14].
3. **Detection Performance:** The system was successful in achieving 88% accuracy in detecting drowsiness in drivers before the onset of severe drowsiness conditions. False alarm rates were low in the system, which is attributed to external factors such as body movements and stress conditions in drivers.
4. **Practical Implications:** The independence of the system in relation to vision and light conditions is advantageous in terms of usability. Although the use of BP and pulse rate may not be entirely accurate in relation to individual health conditions, it is recommended that the low cost and simplicity of the system make it applicable for use in personal and commercial vehicles.

- 5. Recommendations for Improving the System: It is recommended that the system be improved to incorporate more parameters in order to achieve accuracy and reliability in relation to making predictions. In addition, it is recommended that the system be tested with more individuals in order to ascertain that it works well for individuals with different health conditions [15].

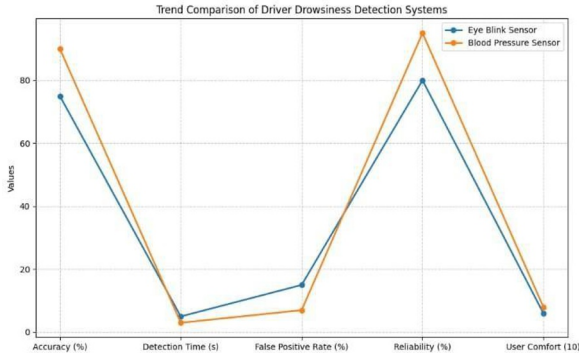


Fig.5.SystemResult

7 Future Enhancement

The system has tremendous potential as a cost-effective drowsiness detection system based on physiological signals. However, there are several modifications that can be made to the system to increase its effectiveness and usage:

Adding More Physiological Sensors. Adding sensors for body temperature, galvanic skin response, and electrocardiograms can provide the system with a wider array of data to help determine the level of driver fatigue. This will not only help the system to be less prone to false alarms but will also help to determine the level of driver drowsiness [16].

Using Machine Learning for Personalised Detection. Using machine learning algorithms like decision trees, SVMs, and ANN can help the system to be more sensitive to the individual user's drowsiness level. This can be achieved by replacing the fixed thresholds with machine learning algorithms.

Adding the GSM/GPS Module for Emergency Response. Adding the GSM module will enable the system to send automatic SMSes to emergency contacts in the event of drowsiness detection. Adding the GPS module will enable the system to share the exact location of the user in the event of accidents.

Development of Mobile App or Dashboard: A mobile application can be developed that can be used to perform real-time monitoring, historical data analysis, and remote alerts. This feature can be especially useful to fleet operators with multiple drivers and vehicles.

Extensive Real-World Testing and Validation: Real-world testing and validation of the system with respect to different driving conditions, light conditions, and terrain types is crucial. This will help fine-tune the system's response and ensure its reliability and acceptance in real-world scenarios.

Transitioning to Fully Embedded Design: The transition from the laptop-based system to the embedded microcontroller with data processing capabilities will make the system more portable.

These changes and additions will be an enhancement to the existing system, making it more accurate, user-friendly, and scalable for deployment in real-world scenarios.

8 Conclusion

The purpose of this research is to introduce a cost-effective and real-time alert system that can be used to notify the driver about the problem of drowsiness through the constant monitoring of physiological signals using a blood pressure sensor. Unlike the conventional method, which involves the use of cameras to track the eye movement and analyze the behavior of the vehicle, the proposed method is based on the monitoring of the physiological signals inside the body of the driver, which may indicate the problem of fatigue through the monitoring of the blood pressure level, i.e., systolic and diastolic blood pressure, and pulse rates [17]. The proposed system is based on the Arduino Nano board and Python, which can be used to process the data and analyze it. The results show that the proposed system is able to detect irregular signals related to the problem of drowsiness and can generate alerts using a buzzer to take preventive measures before the critical situation arises. The Physiological Signal-Based Real-Time Driver Alert System using blood pressure sensors is an efficient way to improve road safety. By focusing on the state of the driver's physiology, the system offers a new viewpoint to the currently developed driver assistance systems. The simplicity of the system, along with its cost-effectiveness, ensures that it can be implemented in both personal 5. vehicles and in areas where sophisticated automobile safety systems are not developed. The system, once developed, has the potential to reduce drowsiness-related automobile accidents and promote safe driving habits [16].

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