Driver Drowsy Detection with IoT-Based Vehicle Control System

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ABSTRACT

The Driver Drowsy Detection System using Deep Learning with an IoT-based Automatic Vehicle Control System is designed to enhance road safety by detecting driver fatigue and taking automated corrective actions. This system leverages a combination of deep learning algorithms, real-time image processing, and IoT-based vehicle control mechanisms. Using OpenCV and Dlib, it monitors the driver's facial features, specifically tracking eye movements to detect signs of drowsiness. Once signs of fatigue are detected, the system uses NodeMCU to communicate with various vehicle components, including a relay, motor, and vibrator motor, to trigger automated responses. These responses can include vibrating the seat or controlling the vehicle's speed to prevent accidents. The system is integrated with Blynk IoT, allowing remote monitoring and alerts to be sent to the driver or vehicle operator. This solution offers a proactive approach to preventing accidents caused by driver fatigue, combining deep learning with IoT to create a safer driving environment.

1. INTRODUCTION

Based on 2017 police and hospital reports, the National Highway Traffic Safety Administration (NHTSA) identified 91,000 car accidents as being caused by drowsy drivers. These accidents resulted in 50,000 injuries. In 2019, 697 fatalities involved a drowsy driver. However, NHTSA admits that it is hard to determine the precise number of drowsy-driving accidents, injuries, or deaths and that the reported numbers are underestimates. For example, a study by the American Automobile Association's foundation for traffic safety estimated that more than 320,000 drowsy driving accidents happen each year, including 6400 fatal crashes. The high numbers indicate that drowsy driving is a serious concern that needs to be addressed to mitigate its impact.

Drowsiness refers to sleepiness, often in inappropriate situations. Although the state of drowsiness may only last for a few minutes, its consequences can be disastrous. The reason for entering such a state is usually attributed to fatigue, which diminishes attention and alertness levels. Drowsiness may happen either by driving for long distances without enough sleep or driving at a time when the driver would typically be asleep. In such cases, the main problem is the drowsy driver's lack of concentration, resulting in a delayed response to any event on the road.

Fortunately, it is possible to detect driver drowsiness in its early stages and alarm the driver to avoid any potential accident. Drowsy drivers exhibit various signs, which include repeated yawning, frequent eye closure, and repeatedly departing street lanes. In fact, driver drowsiness detection (DDD) techniques have been researched intensively in recent years. Researchers have proposed various measures to detect these drowsiness signs as early as possible, in order to avoid accidents. These measures can be divided into four main categories: firstly, image-based measures that are obtained using a camera to analyse the driver's movements and facial expressions; secondly, biological-based measures that relate to the driver's bio-signals and can be recorded by placing special sensors on the driver's body; thirdly, vehicle-based measures, which depend on monitoring the behaviour and movement of the vehicle; finally, hybrid-based measures, using two or more measures. According to the literature, in 2019, Ramzan et al, presented a comprehensive analysis for the existing DDD methods, as well as a detailed analysis for the commonly used classification techniques in thissector. Ramzan et al. classified the DDD techniques into three categories: behavioural, physiological, and vehicular parameter-based techniques. Then, they reviewed the top supervised learning techniques used in detecting drowsiness. In the end, they discussed the prosand cons of the three DDD in a comparative study. On the other hand, Sikander and Anwar presented an in-depth review of the recent advancements in the field of driver fatigue detection. In this review, the DDD methods were categorized into five groups, depending on the extractedfatigue features, including physical features, vehicular features, biological features, subjective reporting, and hybrid features. Furthermore, the fatigue effect on driving performance was discussed, along with the existing commercial products for fatigue detection available on the market. Additionally, Dong et al. presented a review of driver inattention monitoring technologies. Inattention consists of distraction and fatigue. Dong et al. summarized the detection measure into five groups, similar to Sikander and Anwar's work. In their review, Dong et al. introduced the concept of driver inattention and its effect on driving performance. Additionally, they covered some of the commercial products related to inattention detection, along with a detailed review of previous research on inattention detection.

This review contributes to the literature by covering the recently implemented DDD systems, especially those published over the past three years. Our paper classifies these systems into four categories, based on the measures used to determine the state of drowsiness. From our perspective, these measures can be image, biological, vehicle, or hybrid-based.

Moreover, the review lists and tabulates the used parameters, sensors, extracted features, methods and classifiers, and quality metrics (including accuracy, sensitivity, and precision), in addition to the datasets for each system. Additionally, a comparison between the practicality and reliability of each of the four DDD categories is presented. Additionally, the paper covers the recent challenges in the DDD area. Furthermore, we discuss the DDD's future trends and research directions that utilize smartphones, edge computing, and the Internet of Things (IoT).

Existing System

The majority of the driver tiredness detection systems in use today rely on manual interventions or simple camera setups. Infrared sensors are used by certain car monitoring systems to identify eye closure, but these systems frequently lack the sophistication required for precise and prompt fatigue diagnosis. Furthermore, when weariness is identified, they do not automatically take corrective action by integrating with the vehicle control systems. This results in a reactive rather than proactive approach to road safety since there could not be a prompt reaction to stop an accident even if a motorist exhibits symptoms of fatigue.

Proposed System

The suggested Driver Drowsy Detection System analyses face features, especially eye movements, utilizing deep learning algorithms for real-time image processing to track driver alertness. The system monitors sleepiness indicators using OpenCV and dlib, and when it detects one, it uses NodeMCU to interface with car components and initiate automatic remedial procedures. The driver's seat may vibrate, the speed of the car may be changed, or notifications may be sent via an integrated Blynk IoT system for remote monitoring. This creative method integrates deep learning and Internet of Things technologies, offering a proactive way to improve driver safety by averting fatigue-related collisions. The system functions in multiple stages, starting with face and eye detection using a camera positioned on the dashboard to continuously capture the driver's facial expressions. These images are processed in real time using Haar cascade classifiers and PerClos (Percentage of Eye Closure) algorithms to determine whether the driver's eyes remain closed beyond a safe threshold. If the driver's Eye Aspect Ratio (EAR) drops below a set value for a defined number of frames, the system interprets this as a sign of drowsiness.

2. LITERATURE SURVEY

In recent years, the issue of drowsy driving has gained significant attention due to its critical role in causing road accidents and fatalities. Numerous studies have explored various methods for detecting driver fatigue in an effort to develop systems that can prevent such accidents. Ramzan et al. (2019) conducted a comprehensive review of existing driver drowsiness detection (DDD) methods and classified them into three main categories: behavioral, physiological, and vehicular parameter-based techniques. They also evaluated the effectiveness of various supervised learning algorithms for drowsiness detection. Similarly, Sikander and Anwar presented a detailed study highlighting advancements in driver fatigue detection by categorizing techniques based on physical features, vehicular behavior, biological signals, subjective reports, and hybrid features. They also discussed commercial fatigue detection products currently available on the market. Dong et al. contributed to the literature by reviewing driver inattention monitoring technologies, combining both fatigue and distraction under the umbrella of inattention. They grouped detection techniques into five categories and explored their effect on driving performance, along with a discussion of existing commercial tools. These studies indicate that behavioral signs—such as eye closure, blinking rate, yawning, and head movement—are strong indicators of driver fatigue and can be effectively monitored using image-processing technologies.

Despite significant advancements, many existing systems still have limitations. These include reliance on manual interventions, limited feature tracking (e.g., only eye closure), lack of IoT integration, and no automated vehicle response. Most current systems either alert the driver with basic alarms or require the driver to wear intrusive equipment, which may not be practical or comfortable.

To address these limitations, the proposed system integrates deep learning and IoT technologies to monitor driver drowsiness more effectively and non-invasively. It uses computer vision techniques to track facial features in real-time and triggers alerts or corrective actions when signs of fatigue are detected. This approach enhances accuracy, comfort, and safety while enabling real-time monitoring and automated responses, distinguishing it from previous systems and making it a more robust and scalable solution for modern intelligent transport environments.

3. METHODOLOGY

Python:

Python is an interpreter, high-level, general purpose programming language created by Guido Van

Rossum and first released in 1991, Python's design philosophy emphasizes code Readability with its notable use of significant Whitespace. Its language constructs and object- oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Python is dynamically typed and garbage collected. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming.

OpenCV

OpenCV (open-source computer vision) is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by willow garage then Itseez (which was later acquired by Intel). The library is cross platform and free for use under the open-source BSD license. OpenCV supports some models from deep learning frameworks like TensorFlow, Torch, PyTorch (after converting to an ONNX model) and Caffe according to a defined list of supported layers. It promotes Open Vision Capsules which is a portable format, compatible with all other formats.

Scipy

The SciPy library depends on NumPy, which provides convenient and fast N- dimensional array manipulation. The SciPy library is built to work with NumPy arrays and provides many user-friendly and efficient numerical practices such as routines for numerical integration and optimization. Together, they run on all popular operating systems, are quick to install and are free of charge. NumPy and SciPy are easy to use. The basic data structure used by SciPy is a multidimensional array provided by the NumPy module. NumPy provides some functions for Linear Algebra, Fourier Transforms and Random Number Generation, but not with the generality of the equivalent functions in SciPy. but powerful enough to depend on by some of the world's leading scientists and engineer.

Numpy

NumPy is a programming language, adding support for large, multi-dimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays. The ancestor of NumPy, Numeric, was originally created by Jim with contributions from several other developers. In 2005, Travis created NumPy by incorporating features of the competing Num array into Numeric, with extensive modifications. NumPy is open-source software and has many contributors.

Pygame

Pygame is a python wrapper module for the SDL multimedia library. It contains python functions and classes that will allow you to use SDL's support for playing cdroms, audio and video output, and keyboard, mouse and joystick input.

Dlib

Dlib contains machine learning algorithms and tools for creating complex software in C++ to solve real world problems. It is used in both industry and academia in a wide range of domains including robotics, embedded devices, mobile phones, and large high-performance computing environments. Dlib's open source licensing allows you to use it in any application, free of charge. There is no installation or configure step needed before you can use the library. Among other applications of Dlib, this package also contributes mostly to image processing techniques

4-RESULTS

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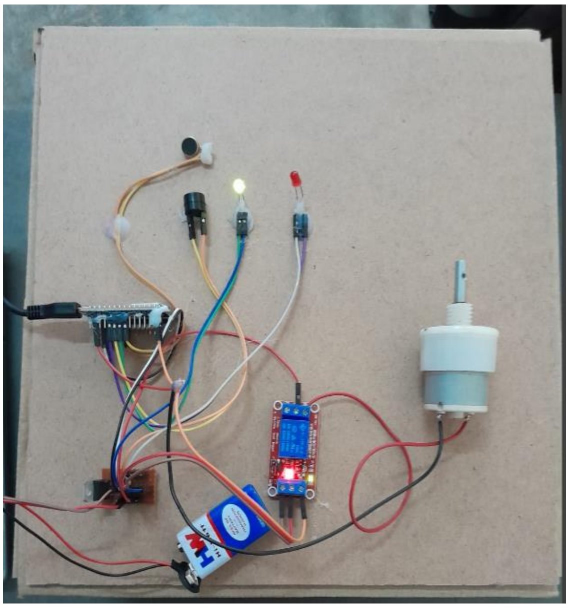
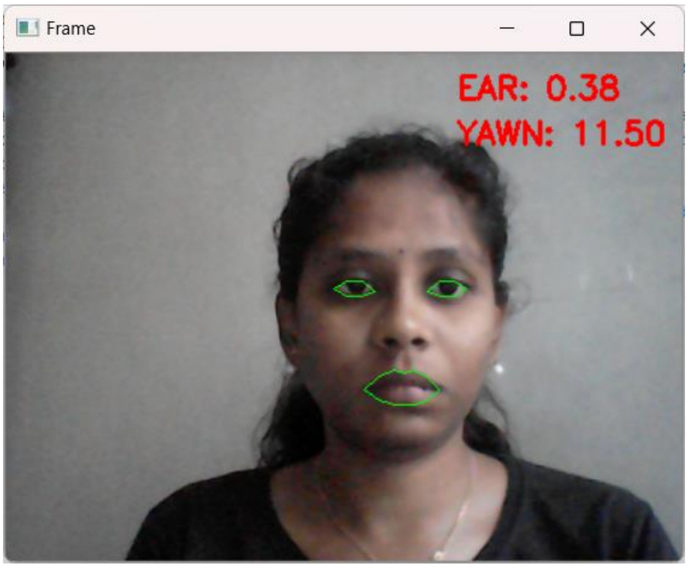
The setup includes a NodeMCU, motor, buzzer, red & green LEDs, and a vibration motor. This hardware receives drowsiness alerts from the vision module (Laptop) and responds in real time.



Screenshot 1 Hardware setup of IoT devices

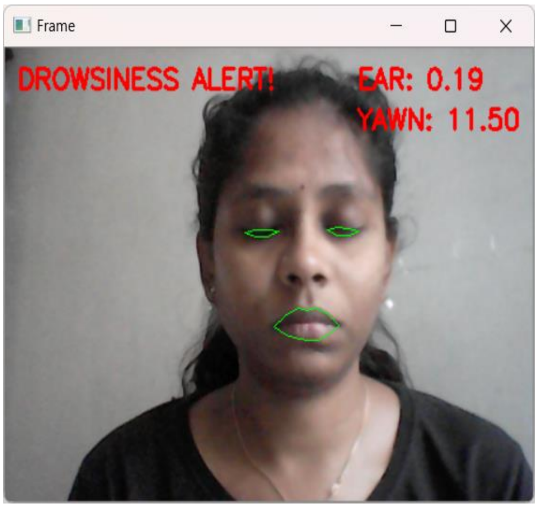
The webcam captures the driver's face in real time. The Eye Aspect Ratio (EAR) and Mouth Aspect Ratio (MAR) are calculated using facial landmarks to detect eye closure and yawning.



Screenshot 2 Facial Landmark Detection

When eye closure is detected for a threshold duration, a '1' is sent to the NodeMCU. NodeMCU shuts off the motor, activates the buzzer, red LED, and vibration, while turning off the green LED.

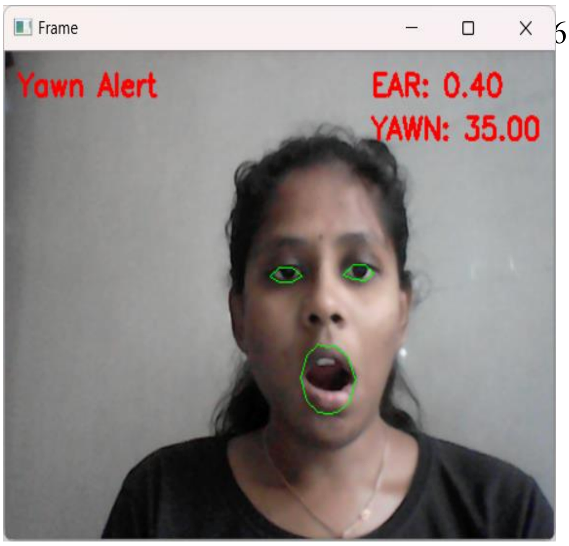
Yawning is detected using lip distance analysis. Similarly like Drowsiness Alert! NodeMCU shuts off the motor,



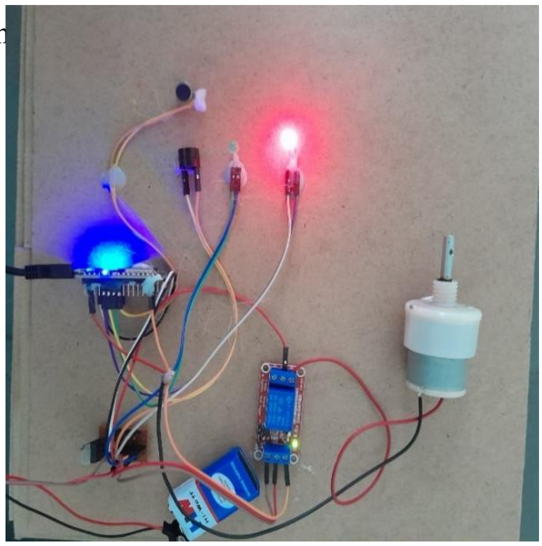
Screenshot 3 Eye Closure Detected

Screenshot 4 Drowsiness Alert

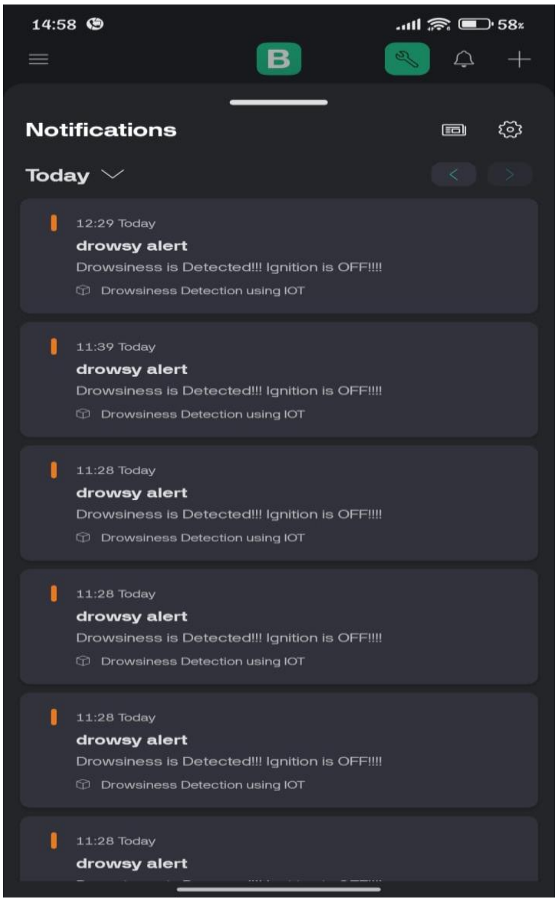
activates the buzzer, red LED, and vibration, while turning off the green LED. Blynk app provides real-time remote monitoring. When drowsiness is detected, it sends alerts and logs events to the cloud.
Additionally, the system sends alert emails to the registered email address.



6.8 Em



Screenshot 5 Yawn Detected



Screenshot 7 Blynk IoT Dashboard

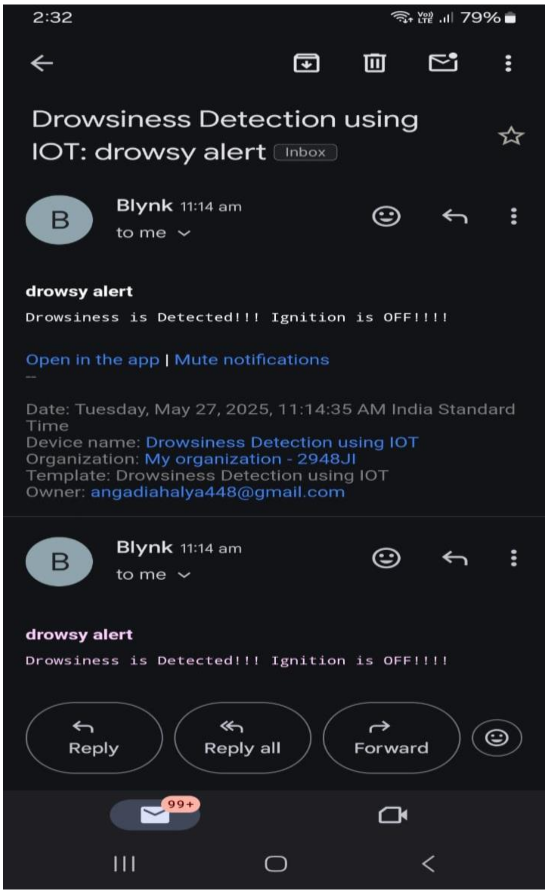
This screenshot shows the Blynk IoT dashboard which connects with the NodeMCU. It provides a remote monitoring interface to view the status of the system in real time sending notification to registered email.

CONCLUSION & FUTURE SCOPE

The Driver Drowsy Detection System combines deep learning and IoT for real-time fatigue detection and automated responses. This scalable solution enhances road safety, reduces accidents, and integrates innovative technology for a safer driving experience.

FUTURE SCOPE

The Driver Drowsy Detection System can be improved by adding advanced facial expression analysis. By detecting subtle facial cues such as head tilting and relaxed facial muscles, the system can



Screenshot 6.8 Email Alert

accurately identify not only drowsiness but also emotional states like stress or distraction. This enhanced system can be applied beyond driving scenarios, such as in IT companies to monitor the alertness of employees working night shifts, ensuring productivity and health.

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