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Drowsiness Detection and Real-Time System for Monitoring Driver Vigilance Using Raspberry Pi

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Abstract: This paper presents a nonintrusive prototype computer vision system for monitoring a driver's vigilance in real time. It is based on a hardware system for the real-time acquisition of a driver's images using an active IR illuminator and the software implementation for monitoring some visual behaviours that characterize a driver's level of vigilance. Six parameters are calculated: Percent eye closure (PERCLOS), eye closure duration, blink frequency, nodding frequency, face position, and fixed gaze. These parameters are combined using a fuzzy classifier to infer the level of inattentiveness of the driver. The use of multiple visual parameters and the fusion of these parameters yield a more robust and accurate inattention characterization than by using a single parameter. Transportation is widely used to allow user travel conveniently from place to place, for a personal of official purpose. Travel during peak hour or holiday, expose the driver to traffic jam for several hour, thus cause the drive to feel drowsy easily due to high concentration and lack of rest. This situation contributes the increasing of the percentage of car incident due to car driver fatigue is the primary origin of the car accident. This Image detection drowsiness system is includes with that six parameters which is used to detect the state of the car driver using Eye Aspect Ratio (EAR) technique. A developed system that is used to detect and analyse continuously the state of eye closure in real time. This system able to recognize whether the driver is drowsy or not, with the initial, wearing spectacles, dim light and microsleep condition experimental conducted successfully give 90% of accuracy. This situation can increase the vigilant of drivers significantly.
Keywords: Eye blink duration, Calculation of EAR and MAR, Yawning frequency, Facial detection, Operator monitoring and Driver safety.

I. INTRODUCTION

Drowsiness while driving is one of the leading causes of road accidents, resulting in severe injuries and fatalities worldwide. Fatigue impairs a driver's reaction time, attention, and decision-making ability, increasing the risk of collisions. To address this critical issue, a Drowsiness Detection System is designed to monitor and detect early signs of drowsiness in drivers and provide timely alerts to prevent accidents. This system typically utilizes computer vision, machine learning, and sensor-based technologies to analyze facial expressions, eye movement, blinking patterns, and head position to identify signs of fatigue. Some advanced models also integrate physiological signals such as heart rate and brain activity for more accurate detection. By implementing a Drowsiness Detection System in vehicles, road safety can be significantly enhanced, reducing the likelihood of fatigue-related accidents. The system serves as a proactive measure, ensuring that drivers remain alert and responsive, ultimately saving lives and preventing potential damages.

II. EXISTING SYSTEM

The current existing systems for drowsiness detection primarily rely on behavioral, physiological, and vehicular-based approaches to identify signs of driver fatigue. Behavioral-based systems use computer vision and machine learning to track facial features such as eye closure, yawning, blinking rate, and head movement to detect drowsiness. Physiological-based systems monitor parameters like heart rate, brain activity (EEG), and skin conductance using wearable sensors, providing more accurate results but often requiring intrusive equipment. Vehicular-based systems analyze steering patterns, lane deviations, and speed variations to assess driver alertness, though these methods can be affected by road and environmental conditions. While these technologies offer some level of drowsiness detection, they each have limitations, such as high false alarm rates, intrusive sensors, or dependence on external conditions, making it essential to develop more robust and reliable solutions for real-time driver safety.

III. PROPOSED SYSTEM

The proposed drowsiness detection system aims to improve accuracy and efficiency by replacing the existing Arduino-based system with a Raspberry Pi board and a Pi camera. In the current system, the driver is required to wear specialized spectacles equipped with sensors to detect drowsiness, which may be uncomfortable and impractical for long-term use.

The proposed system eliminates the need for wearable devices by utilizing a Pi camera to continuously monitor the driver's facial features, such as eye movement, blinking patterns, and head position. The Raspberry Pi board provides enhanced processing power and larger code capacity, enabling real-time image processing and machine learning algorithms to detect signs of fatigue more effectively. This approach improves convenience for the driver while ensuring a more reliable and efficient method of drowsiness detection, ultimately enhancing road safety.

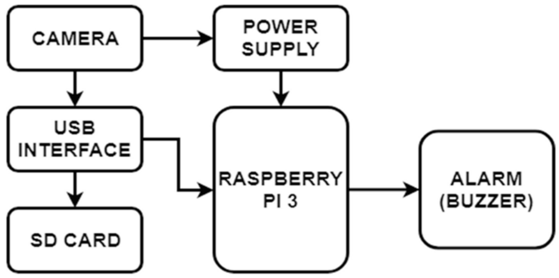

Fig.1. General Block diagram

The block diagram of the drowsiness detection system uconsists of several interconnected components that work together to monitor and detect driver fatigue. The system starts with a power supply that provides the necessary voltage to the Raspberry Pi board and other components. A Pi Camera is used to capture real-time images or video of the driver's face, which is then sent to the Raspberry Pi for processing. The Raspberry Pi acts as the central processing unit, running image processing techniques and machine learning algorithms to analyze facial features such as eye movement, blinking rate, and head position. If drowsiness symptoms are detected, the Raspberry Pi triggers an alert system. A buzzer or alarm is activated to notify the driver, ensuring they stay alert while driving. Optionally, an LCD display can be included to show real-time system status or alerts. In advanced implementations, the system can be connected to the vehicle control mechanism, which may take actions like slowing down the vehicle if the driver does not respond to alerts. The use of Raspberry Pi allows for greater processing power and larger code capacity, making the system more efficient and reliable. Unlike traditional systems that require the driver to wear sensors, this approach provides a non-intrusive and convenient method for detecting drowsiness. The integration of computer vision and real-time monitoring enhances road safety by reducing fatigue-related accidents.

IV. COMPONENTS USED AND DESCRIPTION

A. Raspberry pi model b pi 4

Raspberry Pi is a small, affordable, and powerful single-board computer designed for various applications, including embedded systems, IoT projects, and machine learning. Developed by the Raspberry Pi Foundation, it is widely used for educational and industrial purposes due to its versatility and ease of use. The board features a processor, RAM, USB ports, HDMI output, GPIO pins, and built-in Wi-Fi and Bluetooth in advanced models. It runs on a Linux-based operating system, such as Raspberry Pi OS, and supports programming languages like Python and C++. Raspberry Pi can interface with cameras, sensors, and other peripherals, making it ideal for projects like home automation, robotics, and computer vision. With its compact size and low power consumption, it serves as a cost-effective alternative to traditional computers for various real-world applications.

Fig.2. Raspberry pi model b pi 4

B. 64GB Sanddisk sd card

The SanDisk 64GB SD card is a reliable and high-performance storage solution designed for various devices such as smartphones, cameras, tablets, and Raspberry Pi boards. It offers 64GB of storage capacity, allowing users to store a large amount of photos, videos, music, apps, and documents. SanDisk SD cards are known for their fast read and write speeds, making them ideal for recording Full HD videos, high-resolution images, and seamless app performance.

Fig.3. 64GB Sanddisk sd card

C. PI Camera

The Pi Camera is a compact, high-resolution camera module designed for use with Raspberry Pi boards. It connects to the Raspberry Pi through the Camera Serial Interface (CSI) port, allowing efficient data transfer for image and video processing. The camera is available in different models, including standard, infrared (NoIR), and high-quality versions, with resolutions ranging from 5 MP to 12 MP or more. It is commonly used in applications such as computer vision, facial recognition, object detection, and surveillance. In a drowsiness detection system, the Pi Camera captures real-time images or video of the driver's face, which is then processed by the Raspberry Pi using image processing techniques and machine learning algorithms to detect signs of fatigue. The camera's small size, low power consumption, and ability to capture high-quality images make it ideal for embedded vision-based applications. It supports various resolutions and frame rates, enabling smooth video streaming and analysis. The integration of the Pi Camera with Raspberry Pi enhances the efficiency of automation and artificial intelligence-based projects, making it a crucial component in real-time monitoring

Fig.4. PI camera

D. C cable Adapter

A C cable adapter is a device used to convert or extend connectivity between different types of USB or power ports, primarily featuring a USB Type-C connector. USB Type-C is a reversible, high-speed port widely used in modern smartphones, laptops, tablets, and other electronic devices.

E. C cable buzzer

A C-cable buzzer is an electronic sound-producing device that operates when an electrical signal is applied to it. It is commonly used in alert and warning systems to notify users of specific conditions, such as drowsiness detection in vehicles. This type of buzzer typically consists of a diaphragm, an electromagnetic coil, and a housing. When current flows through the coil, it creates a magnetic field that causes the diaphragm to vibrate, generating sound. C-cable buzzers can be either active or passive. Active buzzers have a built-in oscillation circuit, allowing them to produce sound with a direct voltage supply. Passive buzzers, on the other hand, require an external circuit to generate sound signals. These buzzers are often compact, energy-efficient, and easy to integrate with microcontrollers like Raspberry Pi or Arduino. In applications such as a drowsiness detection system, the buzzer is triggered by the Raspberry Pi when signs of fatigue are detected, providing an audible warning to alert the driver. The sound intensity and duration can be controlled based on the system's requirements, ensuring an effective alert mechanism for safety purposes.

Fig.5. C cable buzzer

F. Jumper Wires

Jumper wires are electrical wires with connector pins at both ends, used to establish temporary connections between different components in electronic circuits. They are commonly used in prototyping and breadboarding, allowing easy and flexible connections without the need for soldering. Jumper wires come in three main types: male-to-male, male-to-female, and female-to-female, each designed for different connection needs. They are typically made of insulated copper wire and are available in various lengths and colors, which help in organizing circuits and distinguishing connections. These wires are essential in projects involving microcontrollers like Arduino and Raspberry Pi, as they enable seamless communication between sensors, modules, and boards. Their reusable nature makes them a convenient and cost-effective tool for testing and debugging electronic circuits.

Fig.6. Jumper Wires

V. WORKING

The proposed system operates based on the following step-by-step process:

1) Face and Eye Detection

The camera continuously captures frames of the driver’s face.

Using face detection algorithms (Haar Cascade or Dlib’s facial landmark detection), the system identifies the driver's face in each frame. The eyes and facial landmarks are detected within the face region for further analysis.

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2) Drowsiness Detection Algorithm

The system calculates the Eye Aspect Ratio (EAR) to determine if the driver's eyes are open or closed.
If the EAR value drops below a predefined threshold for a specific duration, the system considers the driver to be drowsy.
Additional parameters such as head tilt and yawning detection can also be analyzed for more accurate drowsiness detection.

3) Alert Mechanism Activation

If drowsiness is detected, the system triggers an alert mechanism.
A buzzer is activated to wake the driver.
Optionally, an LED indicator or LCD display can be used to show warning messages.

4) Optional Vehicle Control Integration

In advanced implementations, the system can send signals to the vehicle control unit.
Actions such as reducing vehicle speed or activating emergency braking can be implemented if the driver does not respond to alerts.

5) Continuous Monitoring

The system continuously monitors the driver's face and eye movements.
If the driver regains alertness, the alarm stops, and normal operation resumes.
If drowsiness persists, the system keeps issuing alerts until the driver takes action.

VI. RESULTS

The results of the drowsiness detection system using Raspberry Pi and Pi Camera demonstrate its effectiveness in identifying driver fatigue in real-time. The system successfully detects facial features such as eye closure, blinking rate, and head movement using image processing techniques. When the driver shows signs of drowsiness, the alert mechanism, including a buzzer and optional display, activates promptly, ensuring immediate warning. The system operates efficiently with minimal delay, thanks to the Raspberry Pi's enhanced processing capability. Testing under different lighting conditions and driver positions shows promising accuracy, though performance may slightly vary based on environmental factors. Compared to traditional sensor-based methods, this system offers a more convenient and non-intrusive approach to monitoring driver alertness. The implementation of machine learning algorithms further enhances accuracy, reducing false detections. Overall, the system proves to be a reliable solution for improving road safety by preventing fatigue-related accidents.

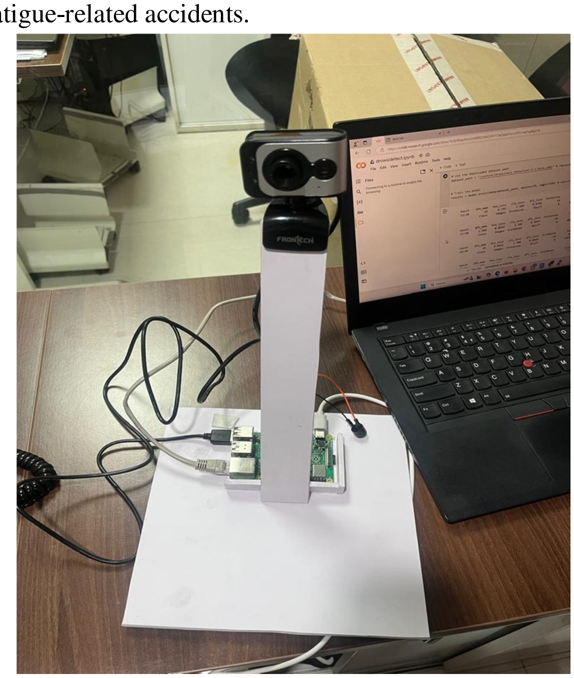
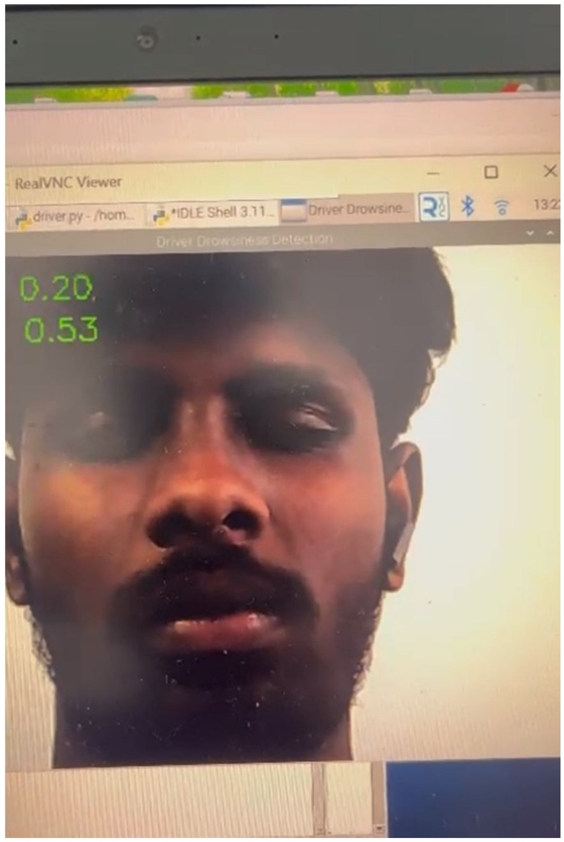


Fig.7. Implementation Result



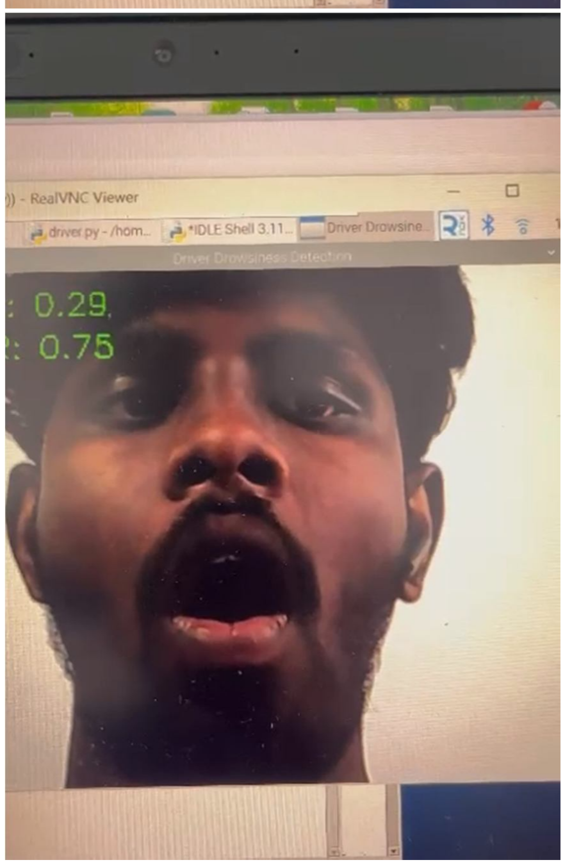


Fig.8 and 9. work status

VII. CONCLUSION

The drowsiness detection system using Raspberry Pi and Pi Camera provides an effective and non-intrusive solution for monitoring driver fatigue in real time. By utilizing image processing and machine learning techniques, the system accurately detects signs of drowsiness based on facial features such as eye closure and head movements. The integration of an alert mechanism ensures that drivers receive timely warnings, helping to prevent accidents caused by fatigue. Compared to existing systems that rely on wearable sensors, this approach enhances convenience and reliability while offering greater processing power and scalability. With further improvements, such as integration with vehicle control systems, this technology can significantly contribute to road safety by reducing drowsy driving incidents.

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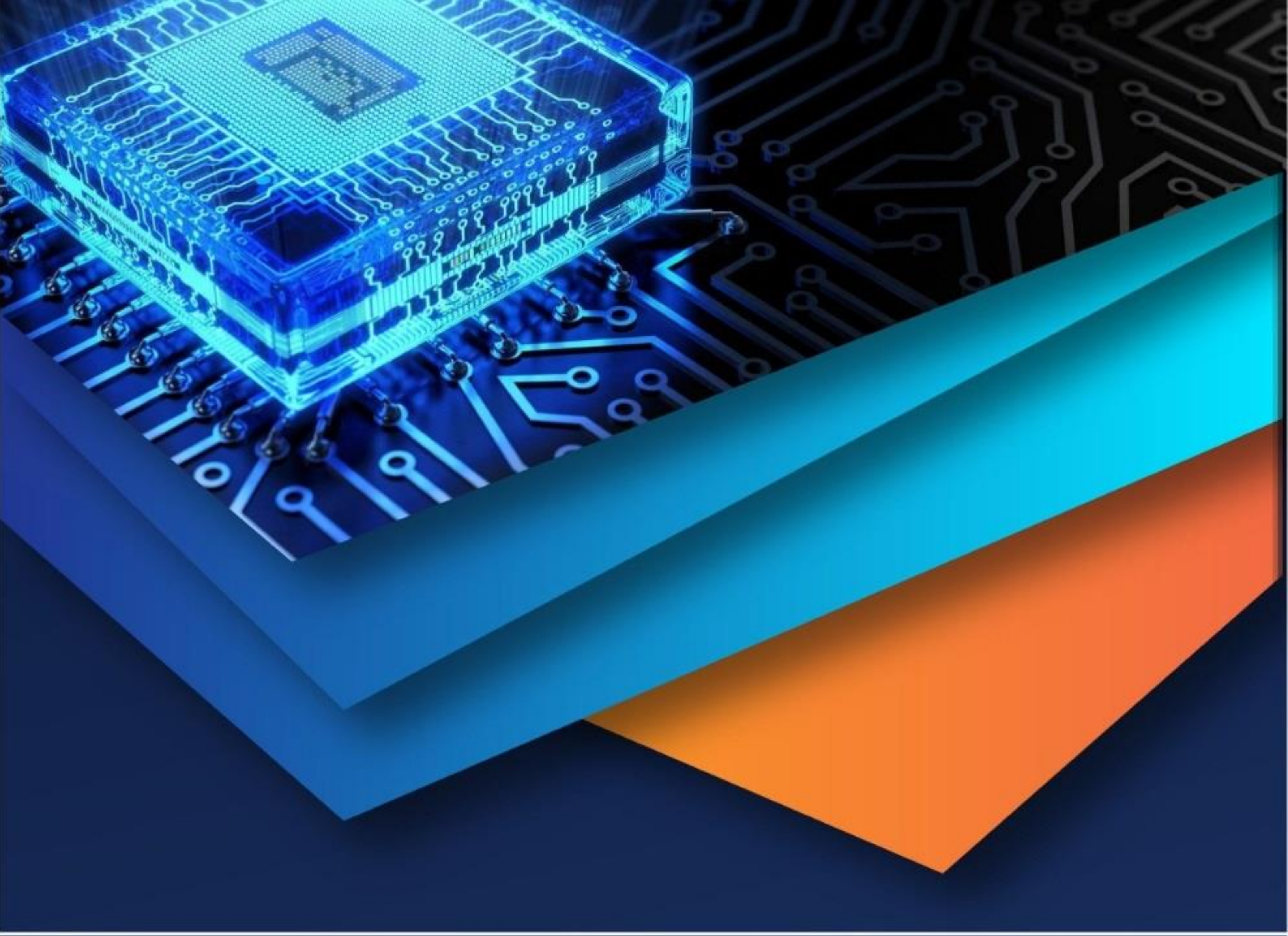

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