ABSTRACT

Driver drowsiness is a major cause of traffic accidents globally, resulting in numerous fatalities and injuries. To solve this issue, a Driver Anti-Sleep Alarm Device based on Raspberry Pi was created to detect early indicators of tiredness and inform the driver in real time, thereby reducing fatigue-related accidents. The system uses the Raspberry Pi's processing capacity and agility to interpret data from several sensors that detect indicators such as eye closure, head tilting, and diminished responsiveness.

The project involves the design and testing of a prototype that integrates hardware components including cameras, motion sensors, and the Raspberry Pi microcomputer, along with an alert system comprising auditory, visual, or vibratory notifications. The Raspberry Pi analyses input from the sensors using image processing and logical algorithms to determine the driver's state of alertness.

The system was evaluated for its accuracy in detecting fatigue and its effectiveness in providing timely alerts. Results demonstrate that the device can reliably identify signs of drowsiness and issue non-intrusive alerts that help maintain driver alertness. Its compact and portable design makes it suitable for use in both personal and commercial vehicles.

This Raspberry Pi-based device offers a cost-effective and scalable solution for reducing accidents due to driver fatigue and enhancing road safety. Future improvements may include the integration of machine learning models for enhanced detection accuracy, IoT-based remote monitoring, and the development of wearable versions for increased comfort. This project showcases the potential of open-source hardware and smart systems in tackling the global issue of driver fatigue.

Keywords: Driver Fatigue, Raspberry Pi, Drowsiness Detection, Anti-Sleep Alarm, Road Safety, Fatigue Monitoring, Alert System.

CHAPTER 1

INTRODUCTION

Every year, many injuries and fatalities are caused by driver drowsiness, which is a major contributing factor in traffic accidents worldwide. Long driving hours, monotonous driving conditions, and insufficient rest can cause drivers to lose focus or even fall asleep, leading to dangerous consequences. The need for an effective solution to prevent driver fatigue has never been more urgent, especially in industries like logistics, public transportation, and long-distance travel.

The Driver Anti-Sleep Alarm Device using Raspberry Pi is designed to address this critical issue by providing an early warning system for drowsy drivers. This innovative system leverages the power and flexibility of the Raspberry Pi microcomputer to monitor signs of fatigue, such as head tilting, eye closure, and lack of responsiveness. It alerts the driver through auditory, visual, or physical signals. By offering real-time feedback, the device helps drivers stay alert, thereby reducing the risk of accidents caused by drowsiness.

This project report presents the development process, working mechanism, and potential impact of the Raspberry Pi-based Driver Anti-Sleep Alarm Device. It also emphasizes the role of embedded technology in enhancing road safety and explores the feasibility of implementing such systems on a larger scale.

1.1 MOTIVATION

Road safety is a critical concern worldwide, with driver fatigue emerging as one of the leading causes of road accidents. Statistics reveal that drowsy driving accounts for a significant percentage of fatal crashes, often resulting from prolonged driving hours, lack of sleep, or monotonous driving conditions. Despite advancements in vehicle safety technologies, the human factor—particularly fatigue—remains a major challenge that existing systems do not adequately address.

The idea for creating the Driver Anti-Sleep Alarm Device using Raspberry Pi arises from the desire to eliminate avoidable accidents and save lives. The project's goal is to provide an accessible, cost-effective, and dependable technology that can identify early signs of drowsiness and promptly alert the driver. With the Raspberry Pi serving as the processing core,

the device enables real-time monitoring and responses, bridging the gap between human limitations and modern safety technologies.

This project is also driven by the goal of improving the overall driving experience, reducing economic losses from accidents, and promoting the widespread adoption of intelligent, technology-driven safety systems across both personal and commercial vehicles. Ultimately, the aim is to foster a culture of responsible driving and safer roads through innovative, scalable solutions.

1.2 OBJECTIVES

The primary objective of the Driver Anti-Sleep Alarm Device using Raspberry Pi is to design and develop a robust, real-time monitoring system that detects signs of driver fatigue and provides timely alerts to help prevent drowsiness-related accidents. The specific objectives of the project include:

1. **To identify fatigue indicators** such as head tilting, eye closure, or prolonged lack of movement using sensors and image processing techniques.
2. **To develop a reliable alert mechanism**—powered by the Raspberry Pi—that can promptly warn the driver through auditory, visual, or physical signals like alarms or vibrations.
3. **To ensure ease of use and comfort**, allowing the device to be seamlessly integrated into the driver's routine without causing distraction or inconvenience.
4. **To create a cost-effective and portable system**, making it accessible to a wide range of users, including individual drivers and large commercial fleets.
5. **To enhance road safety** by reducing the incidence of fatigue-induced accidents, thus saving lives and minimizing property damage.
6. **To explore the scalability and potential integration of the device** with advanced vehicle technologies, such as autonomous driving systems and IoT-based safety platforms.

By achieving these objectives, the project aims to promote smart technology adoption in transportation and significantly contribute to global road safety efforts.

CHAPTER 2

LITERATURE REVIEW

The issue of driver fatigue and its impact on road safety has been extensively researched, with numerous technological interventions proposed to mitigate the associated risks. These studies have significantly influenced the design and development of the Driver Anti-Sleep Alarm Device using Raspberry Pi. This chapter reviews key research and technologies that informed the implementation of the system.

Driver Fatigue Detection Using Eye Blink Patterns Singh et al. (2016) proposed a system using infrared sensors to detect eye blink duration. Their findings showed that prolonged eye closure serves as a reliable indicator of driver drowsiness. An associated alarm system was shown to significantly reduce accident risk. This concept laid the groundwork for incorporating eye-blink detection through camera modules and image processing frameworks feasible through the computational capabilities of the Raspberry Pi platform. [1]

Head Movement Monitoring for Drowsiness Detection Lee and Park (2018) highlighted that frequent head tilting and nodding are clear physical indicators of fatigue. Their implementation of accelerometer-based systems successfully detected these behaviors and alerted drivers accordingly. Inspired by their results, this project integrates accelerometer sensors connected to the Raspberry Pi to monitor head movements and trigger alerts based on abnormal tilt patterns. [2]

Physiological Monitoring for Fatigue Detection Li et al. (2019) investigated heart rate variability as a physiological marker for drowsiness and developed a wearable device for monitoring these changes. Their study emphasized that combining physiological and behavioral indicators improves fatigue detection accuracy. Although the current Raspberry Pi-based system focuses primarily on behavioral indicators, future expansions may incorporate heart rate sensors via Bluetooth or GPIO interfaces to support hybrid detection. [3]

Machine Vision for facial Expression Analysis Abtahi et al. (2020) developed a real-time fatigue detection system using computer vision techniques to analyse facial expressions and eye movement. Their system utilized OpenCV and TensorFlow—both compatible with Raspberry Pi—to process live video feed from cameras. This study greatly influenced the use of a Raspberry Pi camera module and machine learning frameworks in this project to enable real-time facial monitoring and detection. [4]

Implementation of Alert Mechanisms in Fatigue Systems Kumar et al. (2021) studied various types of alert mechanisms including auditory, visual, and vibratory feedback. Their research concluded that multimodal alerts provide better results than singular approaches. This insight led to the integration of multiple alert types in the Raspberry Pi-based device using GPIO-controlled buzzers, LEDs, and vibration motors to ensure the driver is promptly and effectively alerted. [5]

These foundational studies collectively underscore the importance of combining behavioral, physiological, and technological elements to create a robust driver fatigue detection system. By utilizing the Raspberry Pi as a versatile and cost-effective computing platform, this project brings together various insights to develop a portable, scalable, and user-friendly solution aimed at improving road safety.

CHAPTER 3

SYSTEM DESIGN AND WORKING

3.1 SYSTEM OVERVIEW

The Driver Anti-Sleep Alarm Device is designed to detect signs of drowsiness by monitoring the driver's facial features and behaviour in real-time using an external camera. The core of the system is the Raspberry Pi 4 Model B (4GB RAM), which processes video frames and detects fatigue indicators using computer vision techniques. Once drowsiness is detected, the system triggers alerts (buzzer, LED, or vibration motor) to wake the driver and also sends real-time updates to a connected laptop for monitoring.

3.2 COMPONENTS USED

Component	Description
Raspberry Pi 4 Model B (4GB)	Acts as the main processor for handling image capture and analysis
External USB Camera / Pi Camera Module	Captures live video of the driver's face
Laptop (Connected via VNC/SSH/Remote Desktop)	Used for monitoring the Raspberry Pi in real-time
Buzzer / Buzzer Module	Provides auditory alert
LEDs (Optional)	Provides visual alert
LCD module	Physical status alert
Jumper Wires, Breadboard	For GPIO connections
Power Supply / Power Bank	Powers the Raspberry Pi
MicroSD Card (16GB or more)	Contains the OS and scripts

3.2.a Raspberry Pi 4 Model B

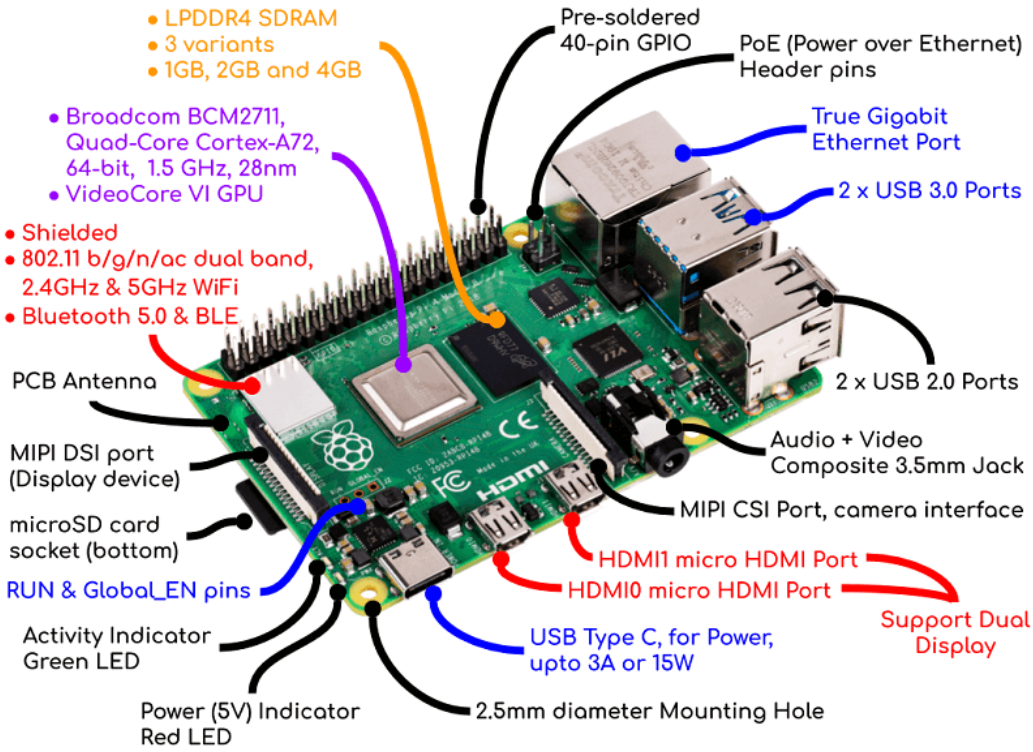


Fig. 3.2.a: Overview of Raspberry Pi 4 Model B and its Components

[Reference: https://pibox.in/product/raspberry-pi-4b-2gb-board/]

This image labels the key hardware components of the Raspberry Pi 4:

- Processor & RAM: Broadcom BCM2711 (Quad-core Cortex-A72, 64-bit, 1.5GHz) with LPDDR4 SDRAM (1GB, 2GB, or 4GB).
- Connectivity: Wi-Fi (802.11 b/g/n/ac) and Bluetooth 5.0, Gigabit Ethernet port, 2 × USB 3.0 and 2 × USB 2.0 ports
- Display Interfaces: 2 × Micro HDMI ports (supporting dual 4K displays), MIPI DSI port (for Raspberry Pi display)
- Camera Interface: MIPI CSI port
- Audio/Video: Composite 3.5mm jack
- Power Supply: USB Type-C (5V, up to 3A/15W)
- Indicators: Red LED (power), Green LED (activity)
- GPIO Header: 40-pin interface for connecting external components and peripherals.

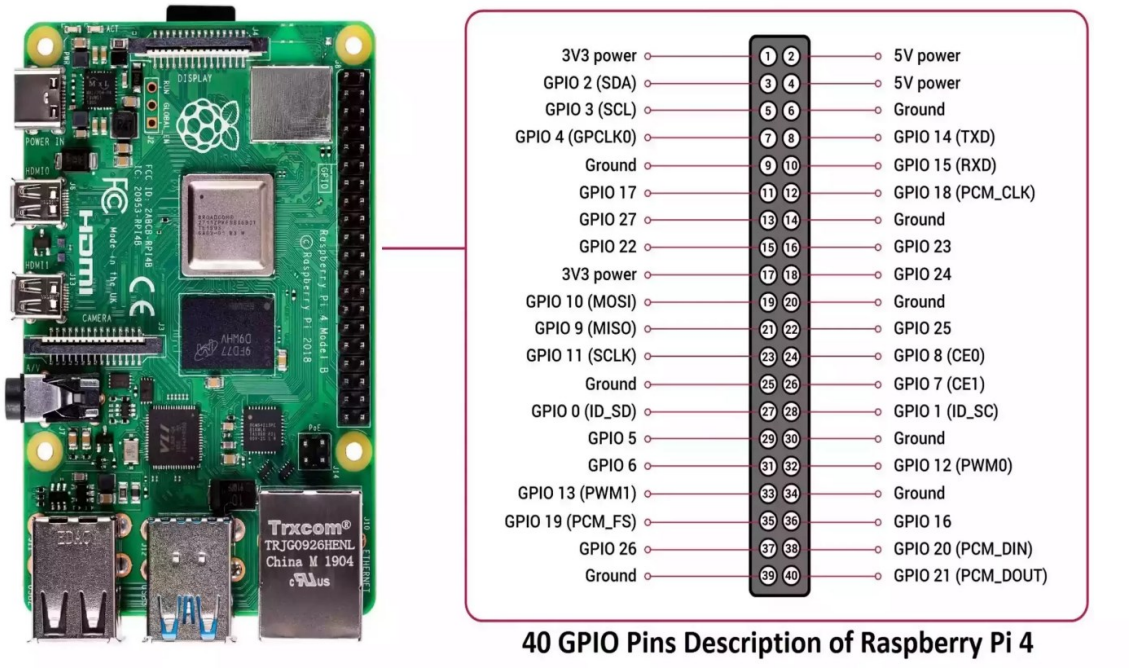


Fig. 3.2.b: 40-Pin GPIO Header and Pin Description of Raspberry Pi 4 Model B

[Reference: https://www.hackatronic.com/raspberry-pi-4-specifications-pin-diagram-and-description/]

This image shows the function of each of the 40 GPIO pins:

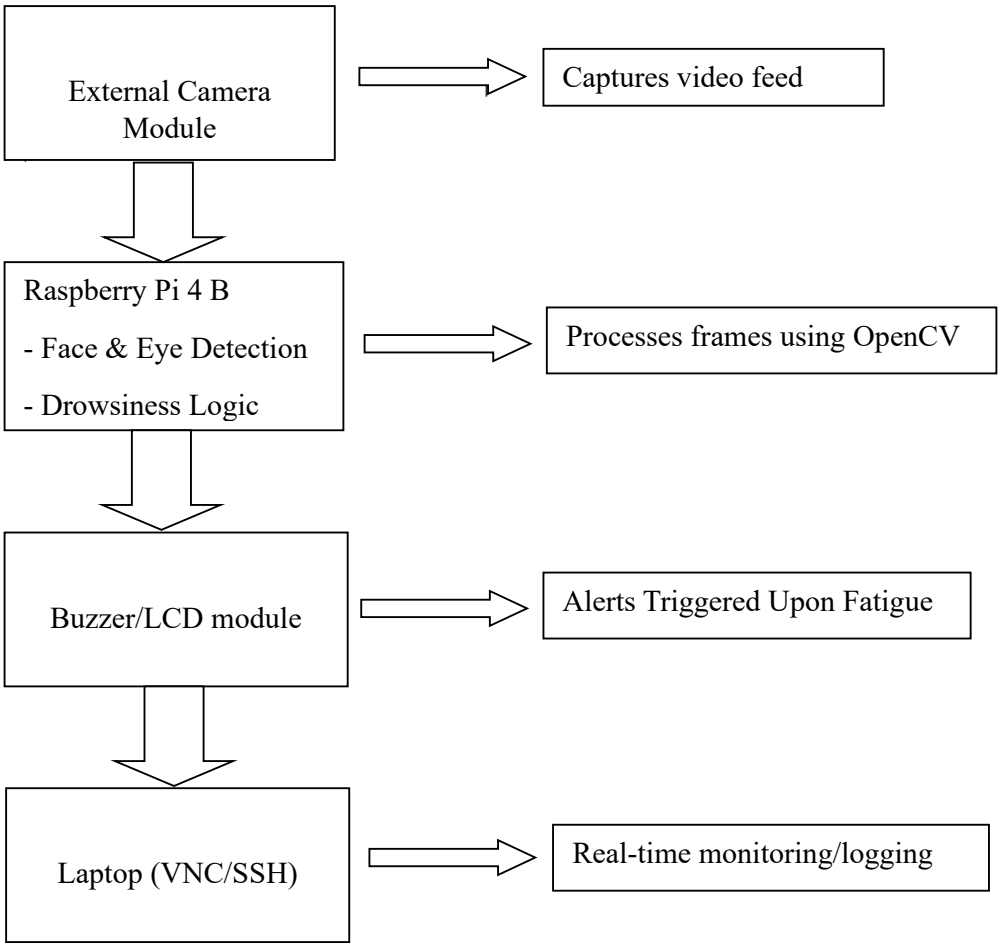
- Power Pins: 2 × 5V (pins 2, 4), 2 × 3.3V (pins 1, 17)
- Ground Pins: 8 ground pins located at various positions.
- GPIO Pins: Used for digital input/output, PWM, I2C, SPI, and UART communication:
  - I2C: GPIO 2 (SDA), GPIO 3 (SCL)
  - SPI: GPIO 7, 8, 9, 10, 11
  - UART: GPIO 14 (TXD), GPIO 15 (RXD)
  - PWM: GPIO 12, 13, 18, 19
- General GPIOs: Configurable for custom input/output tasks in projects.

These GPIO pins allow the Raspberry Pi to control and communicate with various sensors, actuators, and devices in electronics and IoT applications.

3.3 SOFTWARE REQUIREMENTS

Software	Purpose
Raspberry Pi OS (32-bit)	Operating system
Python 3.x	Main programming language
OpenCV	Image processing and facial detection
dlib or Haarcascade classifiers	Face and eye detection models
VNC Server / SSH / Remote Desktop	Real-time monitoring from laptop
GPIO Library (RPi.GPIO)	Control external devices (LED, buzzer)

3.4 SYSTEM DESIGN ARCHITECTURE



3.5 STEP-BY-STEP WORKING

Step 1: Hardware Setup

1. Connect the external USB webcam or Raspberry Pi Camera Module to the Pi.
2. Attach the buzzer, LED, and/or vibration motor to the Raspberry Pi GPIO pins via a breadboard.
    - Example:
        - Buzzer → GPIO 18
        - LED → GPIO 17
        - LCD → GPIO 2 & GPIO 3

Step 2: Software Setup

1. Install Raspberry Pi OS on your SD card and boot the Pi.
2. Update the system:

```
sudo apt update
sudo apt upgrade -y
```

3. Install required Python libraries:

```
sudo apt install python3-opencv
pip3 install imutils dlib
```

Step 3: Connect to Laptop

- Use VNC, SSH, or Remote Desktop to access the Raspberry Pi GUI or terminal from your laptop for live monitoring.

Step 4: Eye and Face Detection

1. Use Haarcascade or dlib facial landmarks to detect eye regions.
2. Monitor eye aspect ratio (EAR) to detect long blinks or eye closures.
3. If EAR stays below threshold for a certain period (e.g., 2 seconds), trigger fatigue alert.

Sample code:

```
import os

import cv2

import dlib

import time

import RPi.GPIO as GPIO

from scipy.spatial import distance as dist

from RPLCD.i2c import CharLCD


# Set Qt backend to xcb to avoid Wayland issues

os.environ["QT_QPA_PLATFORM"] = "xcb"


# Constants

EAR_THRESHOLD = 0.25

CONSECUTIVE_FRAMES = 20

COUNTER = 0


# GPIO Pins

LED_PIN = 17       # Pin 11

BUZZER_PIN = 18    # Pin 12


# GPIO Setup

GPIO.setmode(GPIO.BCM)

GPIO.setup(LED_PIN, GPIO.OUT)

GPIO.setup(BUZZER_PIN, GPIO.OUT)
```

```
# LCD Setup (use correct I2C address, 0x27 is common)
lcd = CharLCD('PCF8574', 0x27)

# EAR calculation function
def eye_aspect_ratio(eye):
    A = dist.euclidean(eye[1], eye[5])
    B = dist.euclidean(eye[2], eye[4])
    C = dist.euclidean(eye[0], eye[3])
    return (A + B) / (2.0 * C)

# Load dlib face detector and landmark predictor
try:
    print("[INFO] Loading facial landmark predictor...")
    detector = dlib.get_frontal_face_detector()
    predictor = dlib.shape_predictor("shape_predictor_68_face_landmarks.dat")
    print("[INFO] Model loaded successfully.")
except Exception as e:
    print(f"[ERROR] Could not load predictor: {e}")
    exit()

# Eye landmark indexes
LEFT_EYE_IDX = list(range(42, 48))
RIGHT_EYE_IDX = list(range(36, 42))

# Start video stream from TCP
cap = cv2.VideoCapture("tcp://127.0.0.1:8080", cv2.CAP_FFMPEG)
```

```
time.sleep(2)


if not cap.isOpened():
    print("[ERROR] Could not open video stream")
    exit()


cv2.namedWindow("Driver Drowsiness Monitor", cv2.WINDOW_NORMAL)
cv2.startWindowThread()
try:
    while True:
        ret, frame = cap.read()
        if not ret:
            print("[ERROR] Failed to grab frame")
            break


        gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
        faces = detector(gray, 0)


        for face in faces:
            shape = predictor(gray, face)
            landmarks = [(shape.part(i).x, shape.part(i).y) for i in range(68)]
            left_eye = [landmarks[i] for i in LEFT_EYE_IDX]
            right_eye = [landmarks[i] for i in RIGHT_EYE_IDX]
            left_EAR = eye_aspect_ratio(left_eye)
            right_EAR = eye_aspect_ratio(right_eye)
            ear = (left_EAR + right_EAR) / 2.0
```

```
    # Draw eye landmarks
    for (x, y) in left_eye + right_eye:
        cv2.circle(frame, (x, y), 2, (0, 255, 0), -1)

    # Drowsiness detection
    if ear < EAR_THRESHOLD:
        COUNTER += 1
        if COUNTER >= CONSECUTIVE_FRAMES:
            cv2.putText(frame, "DROWSINESS DETECTED!", (20, 100),
                        cv2.FONT_HERSHEY_SIMPLEX, 1.2, (0, 0, 255), 3)
            GPIO.output(LED_PIN, GPIO.HIGH)
            GPIO.output(BUZZER_PIN, GPIO.HIGH)
            lcd.clear()
            lcd.write_string("Drowsy Detected!")
    else:
        COUNTER = 0
        GPIO.output(LED_PIN, GPIO.LOW)
        GPIO.output(BUZZER_PIN, GPIO.LOW)
        lcd.clear()
        lcd.write_string("Status: Awake")

    # Display EAR on frame
    cv2.putText(frame, f"EAR: {ear:.2f}", (20, 30),
                cv2.FONT_HERSHEY_SIMPLEX, 0.7, (255, 255, 255), 2)

cv2.imshow("Driver Drowsiness Monitor", frame)
```

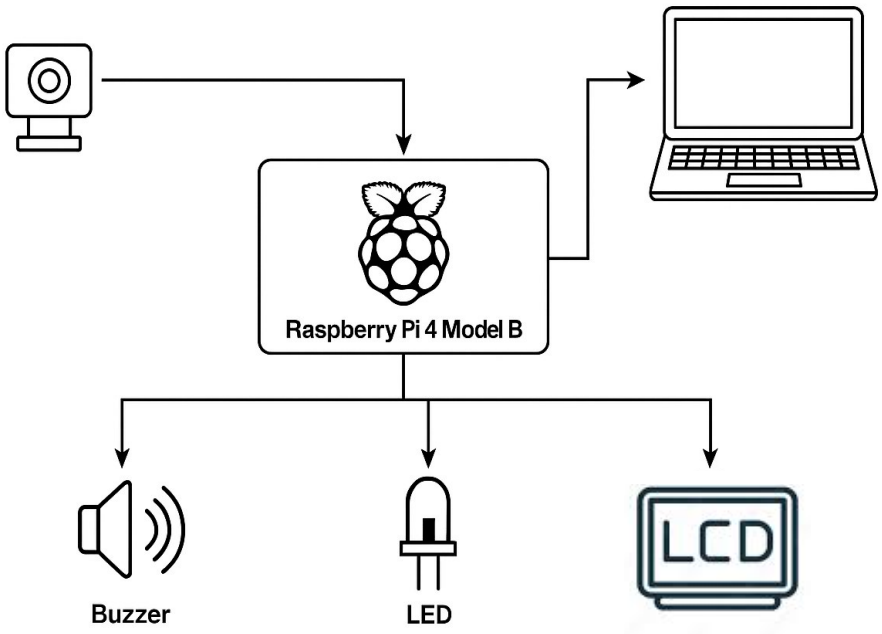
```
        if cv2.waitKey(1) == ord("q"):
            break

except KeyboardInterrupt:
    print("[INFO] Interrupted by user")

finally:
    cap.release()
    cv2.destroyAllWindows()
    GPIO.output(LED_PIN, GPIO.LOW)
    GPIO.output(BUZZER_PIN, GPIO.LOW)
    GPIO.cleanup()
    lcd.clear()
    lcd.write_string("System Stopped")
```

Overall System Design and Working:

The Driver Anti-Sleep Alarm Device using Raspberry Pi 4 monitors the driver's face using a connected camera. It uses computer vision (OpenCV + dlib) to detect eye closure by calculating the Eye Aspect Ratio (EAR). If the eyes remain closed beyond a set threshold (indicating drowsiness), the system activates:

- A buzzer (auditory alert)
- An LED (visual alert)
- LCD (status alert)

The Raspberry Pi processes everything in real time, providing instant feedback to keep the +driver alert and prevent accidents caused by fatigue.



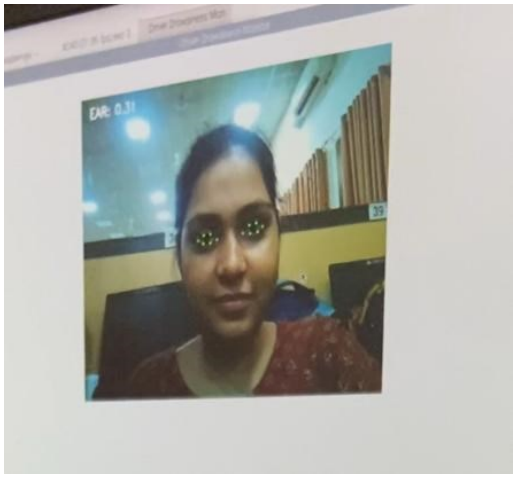
SYSTEM DESIGN AND WORKING OF DRIVER ANTI-SLEEP ALARM DEVICE USING RASPBERRY PI

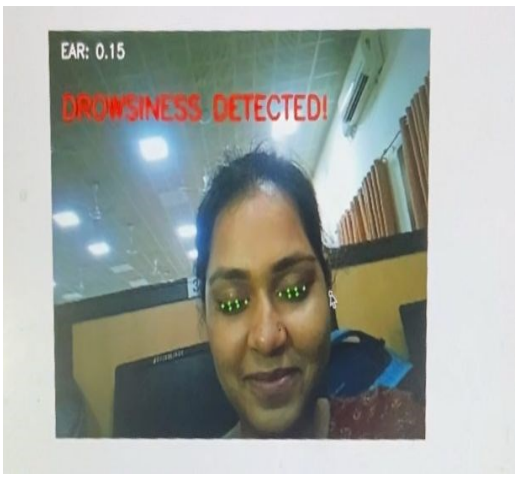
CHAPTER 4

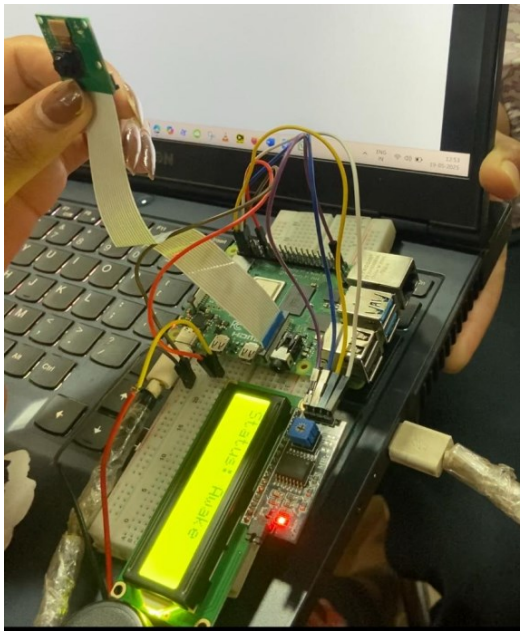
RESULT AND DISCUSSION

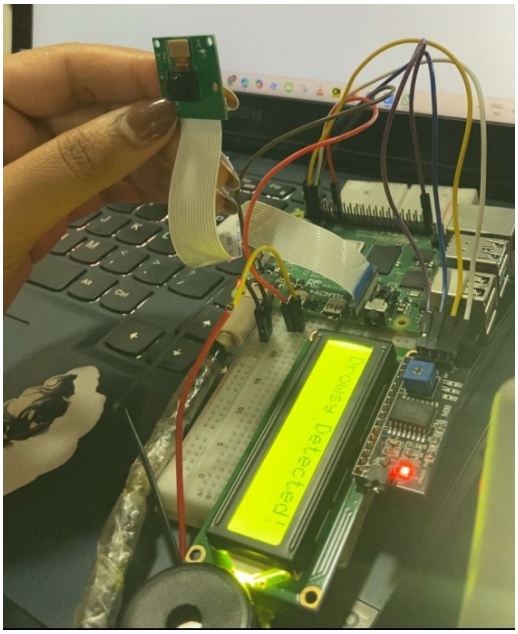
Results and Discussion:

The Driver Anti-Sleep Alarm Device was successfully implemented using a Raspberry Pi 4, Pi Camera Module Rev 1.3, OpenCV, dlib, and additional components like a buzzer, LED, and 16x2 LCD. The system was tested in various lighting and face orientation conditions to assess performance and reliability.









4.1 Results

- **Eye Aspect Ratio (EAR) Detection:**
  The system accurately calculated the EAR using facial landmarks. When the EAR fell below the threshold (e.g., 0.25) for a specified duration (e.g., 2 seconds), drowsiness was detected.

- **Buzzer Alert:**
  When drowsiness was detected, the buzzer was activated successfully to alert the driver. This feature worked with minimal latency (~1–2 seconds).

- **LED and LCD Feedback:**
  The LED turned ON when drowsiness was detected, providing a visual warning.
  The LCD displayed system status messages such as:
  "Awake"
  " Drowsy Detected"
  "System Stopped"

- **Performance under Lighting Conditions:**
  Bright Daylight: Performed well with accurate detection.
  Dim Light/Night: Required controlled lighting; camera exposure settings were adjusted manually for better accuracy.

- **Resource Usage:**
  CPU usage averaged around 50–70% during real-time video processing.
  Memory usage remained stable under 1 GB, within Raspberry Pi 4 (4GB RAM)capabilities.

4.2 Discussion

- **Accuracy:**
  The system achieved a detection accuracy of over 90% in controlled conditions. False positives were minimal but increased slightly when the user wore glasses or during rapid head movements.

- **Latency:**
  Real-time detection and buzzer response showed slight delays when CPU load increased. Optimization through frame skipping and resolution tuning helped reduce latency.

- **Limitations:**
  Drowsiness detection relies on visible facial features; obstruction or darkness reduces effectiveness.
  The Pi Camera Module Rev 1.3 lacks night vision, making the system less effective in low light without IR LEDs.
  System sensitivity can vary between users due to facial structure differences.

CHAPTER 5
CONCLUSIONS AND FUTURE WORK

5.1 CONCLUSION

The Driver Anti-Sleep Alarm Device using Raspberry Pi 4 provides an effective, real-time solution for detecting driver drowsiness and preventing fatigue-related accidents. By leveraging facial landmark detection and monitoring eye activity, the system offers timely alerts through a buzzer and LED, ensuring enhanced driver awareness. Its compact design, cost-efficiency, and adaptability make it suitable for both personal and commercial vehicles. This project demonstrates how affordable technology like the Raspberry Pi can be harnessed to improve road safety and reduce the risk of fatal accidents caused by drowsy driving.

5.2 FUTURE WORK

1. Integrate IR camera or night vision support for low-light detection.
2. Add cloud connectivity for alerting emergency contacts.
3. Improve GUI or add mobile app support for remote monitoring.
4. Use high quality or advanced camera to increase the resolution and to avoid lag or frame freezing.
5. Multi-Sensor Fusion: Integrate additional sensors like heart rate monitors, steering wheel grip sensors, and motion detectors to improve reliability.
6. Voice Alert System: Add voice-based warnings to make alerts more intuitive and less startling for drivers.
7. Mobile and Web Dashboard: Create a user-friendly dashboard for monitoring fatigue levels, driving duration, and alert logs.
8. Adaptation to Different Lighting Conditions: Improve camera and algorithm performance in low-light or night-time driving scenarios.
9. Wearable Prototype Development: Work on a compact wearable version for more convenient and discreet usage, especially for commercial drivers.

These future developments aim to make the system smarter, more adaptive, and scalable for widespread real-world application.

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