

Low-Cost Driver Monitoring System using Deep Learning

¹S K. Nazma, ²Dr. G. Chenchukrishnaiah, ³Dr. P. Srinivasulu, ⁴S K. Moula

M.Tech Scholar, Dept of ECE, Audisankara College of Engineering and Technology, Gudur, Andhra Pradesh,

²Professor, Dept of ECE & Vice-Principal Audisankara College of Engineering & Technology, Gudur, Andhra Pradesh, ³Associate Professor, Dept of ECE, Audisankara College of Engineering and Technology, Gudur, Andhra Pradesh, ⁴Assistant Professor, Dept of ECE, Audisankara College of Engineering and Technology, Gudur, Andhra Pradesh.

Abstract - Driver Monitoring systems are becoming an essential part of Advanced Driver Assistance Systems (ADAS) safety features in modern vehicles. The U.S. National Highway Traffic Safety Administration reports that drowsy/fatigued driving results in almost 100,000 road accidents per year. Driver's fatigue can have different causes, such as lack of sleep, long journeys, restlessness, mental pressure, and alcohol consumption.

Early monitoring systems relied on data from vehicle sensors, and modern systems commonly use driver's eye tracking. Recently, there has been growing interest in utilizing machine vision and deep learning for driver monitoring. Using machine vision can create more advanced driver monitoring systems capable of detecting driver attention state as well as other features like smartphone usage while driving and seat belts.

Machine vision systems usually require extensive processing power, which raises the cost of such systems. In this paper, we present a low-cost driver monitoring system using a Raspberry Pi Zero 2 W board and deep learning CNN to deliver a system capable of monitoring and identifying different states of the driver like safe driving, distracted, drowsy, and smartphone usage. The system achieves an inference rate for 10 Frames Per Second (FPS) and above 90% accuracy with the testing dataset.

In addition to the deep learning CNN which runs on Raspberry Pi CPU, we utilize the Raspberry Pi GPU to run a head pose estimation algorithm to boost the system's accuracy.

INTRODUCTION

Drowsy driving is one of the major causes of fatal road accidents. Studies indicate that nearly 21% of road accidents are related to driver drowsiness, and this percentage continues to rise globally. Driver fatigue, drink-and-drive behavior, and carelessness are major reasons behind such

accidents, affecting many lives and families worldwide.

Therefore, real-time drowsiness detection systems are important to alert drivers and help prevent mishaps. This paper presents a driver drowsiness detection system using OpenCV, Raspberry Pi, and image processing techniques. Various methods have been studied to detect driver drowsiness, including physiological, ocular, and performance-based measures. Physiological measures such as brain waves, heart rate, and pulse rate require physical contact with the driver, which can be uncomfortable during driving. In contrast, ocular measures are non-intrusive and more suitable for real-world applications.

The proposed system uses a camera to monitor the driver's eye state and facial features. By analyzing eye closure duration and blinking patterns, the system can identify signs of drowsiness in advance. When drowsiness is detected, an alarm is activated inside the vehicle to warn the driver.

Face detection and eye detection play a major role in this system, as they are essential for accurately assessing driver alertness. This real-time approach provides an effective and practical solution for reducing accidents caused by driver fatigue.

I. RELATED STUDY

Several studies have been carried out on driver monitoring and drowsiness detection systems to improve road safety. A Raspberry Pi-based driver drowsiness detection system used computer vision techniques to monitor eye closure and facial movements for identifying fatigue conditions in real time. Another study developed a monitoring system using Raspberry Pi and Haar Cascade classifiers for detecting face, eye, and mouth movements, achieving high accuracy in drowsiness and inattentive driving detection. Researchers also proposed integrated safety systems combining driver drowsiness detection with seat belt

monitoring using Raspberry Pi and Arduino. Recent advancements in deep learning introduced Tiny ML-based lightweight models such as Mobile Net and CNN, which achieved high accuracy while running efficiently on embedded devices. OpenCV-based systems using Raspberry Pi have also been widely used to detect prolonged eye closure and generate warning alerts. Furthermore, modern in-cabin monitoring systems running on low-cost edge hardware can identify multiple driver behaviors such as smartphone usage, yawning, distraction, and sleep in real time. The studies show that low-cost embedded systems with computer vision and deep learning are highly effective for developing intelligent driver safety systems.

II. LITERATURE SURVEY

Several studies have been conducted on driver drowsiness detection and monitoring systems. In **“Drowsy Driver Detection Using Representation Learning,”** a CNN-based vision system was proposed to classify drivers as drowsy or alert using facial features such as eye closure and yawning. Another study, **“Fatigue State Detection Based on Multi-Index Fusion,”** used eye and mouth state recognition networks with face detection techniques, achieving high accuracy in fatigue detection.

In **“Integrating Visual Large Language Model and Reasoning Chain for Driver Behavior Analysis,”** researchers developed an advanced distracted driving classification model capable of analyzing driver posture, hand movements, and risk levels. Similarly, **“Attention-Based Multi-Modal Multi-View Fusion Approach for Driver Facial Expression Recognition”** introduced a model using RGB, infrared, and depth images to recognize facial expressions under poor lighting and varying head poses with over 95% accuracy.

For low-power devices, **“Quantization and Training of Neural Networks for Efficient Integer-Arithmetic-Only Inference”** focused on optimizing deep learning models for faster and efficient embedded implementation. In **“DDD Tiny ML: A Tiny ML-Based Driver Drowsiness Detection Model,”** lightweight models such as Mobile Net and CNN were deployed on microcontrollers, achieving excellent accuracy with reduced memory usage.

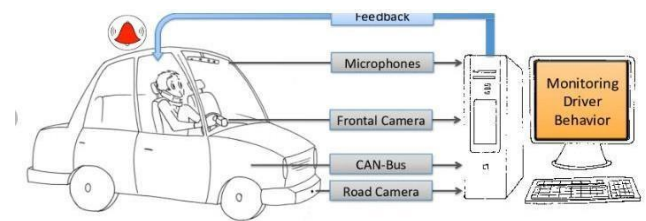
Low-cost practical systems were also developed using Raspberry Pi. In **“Real-Time Driver Alert System Using Raspberry Pi,”** a camera-based system monitored eye closure and generated buzzer alerts. Likewise, **“IoT Based Real-Time Drowsy Driving Detection System”** used Raspberry Pi and eye closure ratio analysis to detect fatigue

and warn drivers. These studies show that computer vision, deep learning, and embedded systems are effective solutions for improving driver safety.

III. METHODOLOGY

4.1 EXISTING SYSTEM

Existing abnormal driver behavior detection systems are either based on driver's health or vehicle monitoring. Driver behavior monitoring can be achieved through either image processing or signal processing [36]. Image processing relies on graphical analyses, utilizing facial expressions captured by a camera to detect driving behavior. This approach employs computer vision techniques to identify drowsy expressions, examining visual features such as eye-state, eye-blinking, and mouth yawning. Image processing-based schemes are not applicable when the driver is wearing black sunglasses or laughing during a talk.



DISADVANTAGES:

The disadvantages of the existing system are:

- Existing systems are less accurate in detecting drowsiness under poor lighting conditions.
- Performance decreases when the driver wears black sunglasses or spectacles.
- Facial expressions such as laughing or talking may produce false detection results.
- Signal processing methods require physical sensors attached to the driver, causing discomfort.
- Vehicle-based monitoring depends on road condition, vehicle type, and driving style.
- Some systems are slow in processing real-time data.
- High-end systems require costly hardware and complex setup.
- Existing systems may fail to detect drowsiness at an early stage.
- Maintenance and calibration are required frequently.
- Reliability decreases in night driving or dark cabin environments.
-

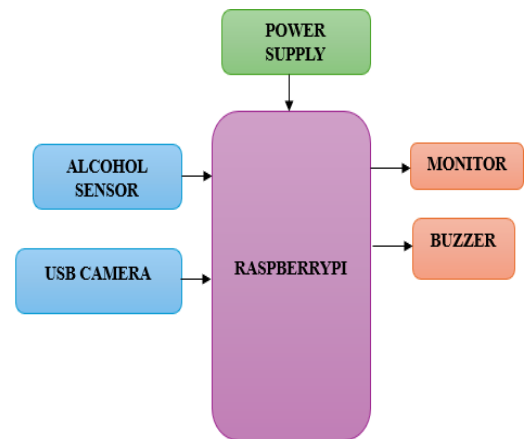
4.2. PROPOSEDSYSTEM:

In the proposed system, the primary focus is given to the faster drowsiness detection and processing of data. The number of frames in which the eyes are kept closed is monitored and then counted. If the number of frames exceeds a threshold value, then a warning message is generated on the display showing that the drowsiness is detected. The system should be capable of detecting drowsiness in spite of the skin colour and complexion of the driver, spectacles used by the driver and the darkness level inside the vehicle. All the se objective shave been well satisfied by choosing the system using appropriate classifiers in OpenCV for eye closure detection. In this algorithm, first a driver's image is acquired by the camera for processing. In OpenCV, the face detection of the driver's image is carried out first followed by eye detection. The eye detection technique detects the open state of eyes only. Then the algorithm counts the number of open eyes in each frame and calculates the criteria for detection of drowsiness. If the criteria are satisfied, then the driver is said to be drowsy. The display and buzzer connected to the system perform actions to correct the driver abnormal behavior.

ADVANTAGESOFPROPOSEDSYSTEM

- Provides fast and real-time driver drowsiness detection.
- Accurately monitors eye closure continuously using camera input.
- Generates instant warning message and buzzer alert to wake the driver.
- Works effectively under different skin colors and facial complexions.
- Detects drowsiness even when the driver wears spectacles.
- Performs well in low light or dark vehicle environments.
- Uses non-contact image processing method, so it is comfortable for drivers.
- Low-cost implementation using Raspberry Pi and OpenCV.
- Easy to install and operate inside vehicles.
- Reduces road accidents caused by fatigue and careless driving.
- Compact, portable, and energy efficient system.
- Reliable and suitable for continuous monitoring.

4.3.BLOCKDIAGRAM:



Block Diagram of a Driver Monitoring/Drowsiness Detection System using Raspberry Pi.

Explanation:

- Power Supply → Provides required power to the Raspberry Pi and connected devices.
- Alcohol Sensor → Detects alcohol presence from the driver and sends data to Raspberry Pi.
- USB Camera → Captures the driver's face/eye movements for drowsiness detection.
- Raspberry Pi → Acts as the main controller that processes sensor and camera inputs using Python/OpenCV.
- Monitor → Displays system status, warnings, or detection messages.
- Buzzer → Produces alarm sound when drowsiness or alcohol is detected.

IV. MODULEDESCRIPTION

5.1 RASPBERRYPI3

Raspberry Pi 3 is a compact and low-cost single-board computer developed by the Raspberry Pi Foundation, UK. It is widely used in embedded systems, robotics, automation, IoT, and educational applications.

Raspberry Pi 3 offers higher performance compared to previous models and is suitable for image processing and real-time monitoring systems.

It is powered by a **Broadcom BCM2837 SoC** with a

1.2 GHz 64-bit Quad-Core ARM Cortex-A53 processor and **1 GB RAM**. It also includes an integrated **Video Core IV GPU**, which supports multimedia and graphics applications.

Unlike normal computers, Raspberry Pi does not have a hard disk. It uses a **Micro SD card** for booting the operating system and storing data. It supports operating

systems such as **Raspbian OS, Linux, Fedora, and FreeBSD.**

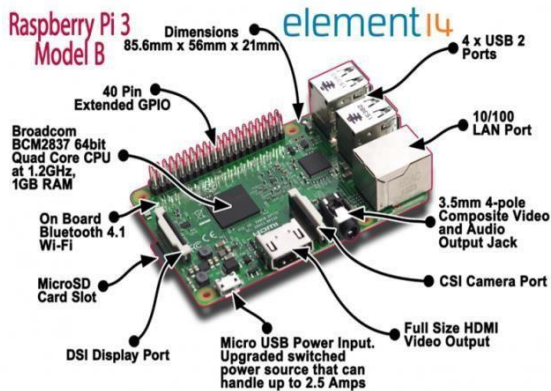


Fig5.1 RaspberryPi-3Board

5.2.USB CAMERA

A digital digicam is an optical device that records photographs that may be saved directly, transmitted to another location, or both. These photographs can be still photographs or shifting photographs such as videos or movies.

The term digital digicam comes from the word digital digicam obscura (Latin for "darkish chamber"), an early mechanism for projecting photographs.

The current digital digicam developed from the digital digicam obscura. The functioning of the digital digicam may be very just like the functioning of the human eye.



5.2.USB Camera

5.3.AlcoholSensorModule-MQ3

This module is made using the Alcohol Gas Sensor MQ3. It is a low-cost semiconductor sensor which can detect the presence of alcohol gases at concentrations from 0.05 mg/L to 10 mg/L. The sensitive material used for this sensor is SnO₂, whose conductivity is lower in clean air. Its conductivity increases as the concentration of alcohol gases increases. It has high sensitivity to alcohol and has a good

resistance to disturbances due to smoke, vapor, and gasoline. This module provides both digital and analog outputs. The MQ3 alcohol sensor module can be easily interfaced with microcontrollers, Arduino boards, Raspberry Pi, etc.

This alcohol sensor is suitable for detecting alcohol concentration on your breath, just like your common breathalyzer. It has a high sensitivity and fast response time. The sensor provides an analog resistive output based on alcohol concentration. The drive circuit is very simple; all it needs is one resistor. A simple interface could be a 0-3.3V ADC.

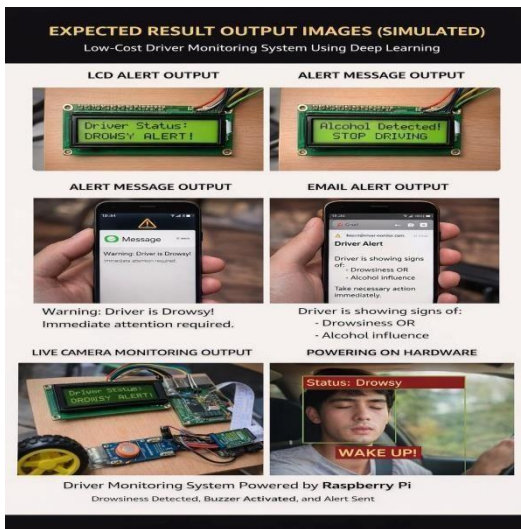
RESULT

The proposed system shows the successful implementation of a low-cost driver monitoring system using Deep Learning and Raspberry Pi for improving road safety. The results demonstrate that the system can effectively detect driver drowsiness through camera-based eye monitoring and identify alcohol consumption using an alcohol sensor. When drowsiness is detected, warning messages such as "Driver Status: DROWSY ALERT!" are displayed on the LCD screen, while additional alerts are sent through mobile messages and email notifications. Similarly, when alcohol is detected, the system displays "Alcohol Detected! STOP DRIVING" to warn the driver. The live hardware setup confirms the practical real-time operation of the prototype, integrating Raspberry Pi, LCD, camera, and sensors. The camera monitoring output also shows accurate face detection and status identification, displaying "WAKE UP!" when the driver is drowsy. Overall, the proposed system proves to be efficient, reliable, and useful in preventing accidents caused by fatigue and alcohol-impaired driving..



The live hardware setup demonstrates the practical implementation of the prototype using Raspberry Pi, camera module, LCD display, alcohol sensor, buzzer, and power supply. The Raspberry Pi acts as the main controller, processing sensor data and executing the deep learning model efficiently in real time. The camera-based monitoring output proves that the system can accurately detect the driver's face and eye status even during

continuous driving conditions.



Overall, the proposed system successfully demonstrates an intelligent and low-cost driver monitoring solution using Deep Learning and Raspberry Pi. It effectively detects driver drowsiness through eye and facial analysis and identifies alcohol consumption using an alcohol sensor. The system provides immediate alerts through LCD messages, buzzer sounds, mobile notifications, and email warnings to ensure quick response and driver safety. The real-time hardware implementation confirms that the system is practical, reliable, and easy to deploy in vehicles. With high accuracy, fast response time, low power consumption, and affordable cost, the proposed system can be widely used in cars, buses, trucks, and other transport vehicles. Hence, it offers an efficient solution to reduce road accidents caused by fatigue, distraction, and drunk driving while improving overall transportation safety.

Results of the Driver Monitoring System



V. CONCLUSION

The driver abnormality monitoring system developed is capable of detecting drowsiness, drunken and reckless behaviours of driver in a short time. The Drowsiness Detection System developed based on eye closure of the

driver can differentiate normal eye blink and drowsiness and detect the drowsiness while driving. The proposed system can prevent the accidents due to the sleepiness while driving. The system works well even in case of drivers wearing spectacles and even under low light conditions if the camera delivers better output. Information about the head and eyes position is obtained through various self-developed image processing algorithms. During the monitoring, the system is able to decide if the eyes are opened or closed. When the eyes have been closed for too long, a warning signal is issued. Processing judges the driver's alertness level on the basis of continuous eye closures.

In future it can implement drowsiness detection system in aircraft in order to alert pilot.

- The alcohol ic sensor is also used for drunk drivers
- In future it can implement drowsiness detection system in schools and colleges to alert the staffs to find the drowsy student in class.

VI. REFERENCES

- [1] A. G. Wheaton, "Drowsy driving and risk behaviors—10 states and Puerto Rico 2011–2012," *MMWR Morb Mortal Wkly Rep.*, vol. 63, no. 26, pp. 557–562, 2014.
- [2] NHTSA, "Drowsy Driving." Accessed: Feb. 27, 2024.
- [3] Canalis, "Autonomous driving starts to hit mainstream." Accessed: Feb. 20, 2024.
- [4] O. Carsten et al., "Control task substitution in semiautomated driving," *Human Factors*, vol. 54, no. 5, pp. 747–761, 2012.
- [5] J. W. Jenness et al., "Use of advanced in-vehicle technology by young and older adopters," NHTSA Report, 2008.
- [6] IDTechEx, "Regulations drivers for mandating driver monitoring systems." Accessed: Feb. 15, 2024.
- [7] U.S. Congress, Senate Bill 1406. Accessed: Feb. 15, 2024.
- [8] M. Q. Khan and S. Lee, "Survey of driving monitoring and assistance systems," *Sensors*, vol. 19, no. 11, p. 2574, 2019.
- [9] S. Titare et al., "Driver drowsiness detection and alert system," *IJSCSEIT*, vol. 7, pp. 583–588, 2021.
- [10] C. Solomon and Z. Wang, "Driver attention and behavior detection with Kinect," *J. Image Graph.*, vol. 3, no. 2, pp. 1–6, 2015.
- [11] J. D. Ortega et al., "DMD: Large-scale multi-modal driver monitoring dataset," *ECCV*, pp. 387–405, 2020.
- [12] B. K. Savas and Y. Becerikli, "Real-time driver fatigue detection using multi-task CNN," *IEEE Access*, vol. 8, pp. 12491–12498, 2020.
- [13] E. Vural, "Drowsy driver detection through facial movement analysis," *HCI Workshop*, pp. 6–18.
- [14] K. Dwivedi et al., "Drowsy driver detection using representation learning," *IEEE IACC*, pp. 995–999, 2014.
- [15] W. Zhang et al., "Driver yawning detection using deep CNN," *IJCNN*, pp. 1–8, 2015.
- [16] Y. Ji et al., "Fatigue state detection based on multi-index fusion," *IEEE Access*, vol. 7, pp. 64136–64147, 2019.
- [17] K. Zhang et al., "Visual large language model for driver behavior analysis," *Accident Analysis & Prevention*, vol. 198, 2024.
- [18] J. Chen et al., "Attention-based multi-modal fusion for facial expression recognition," *IEEE Access*, vol. 12, pp. 137203–137221, 2024.

Paper published with title "A Real-time System for Monitoring Crop and Soil Health in Sustainable Agriculture Using Drones and Artificial Intelligence" in *Journal of Environmental Protection and Ecology* 26, No.

2, 723–733 (2025) (Scopus). Published a paper titled “Medical Image Compression by Optimal Filter Coefficients Aided Transforms using Modified Rider Optimization Algorithm,” International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-9 Issue-2, December 2019 (Scopus).

Kirkpatrick JN, Vannan MA, Narula J, Lang RM (2007) Echocardiography in heart failure: applications, utility, and new horizons. J Am Coll Cardiol 50(5): 381–396.

Paper published with title Fine-Tuned Convolutional Neural Network for Different Cardiac View Classification in Journal of Super Computing published on 2022.

UNDER THE GUIDANCE OF:

Dr. P. Sreenivasulu obtained his Bachelor’s degree in Electronics and Communication Engineering from Sri Venkateswara University, and his Master’s degree in Electronics Instrumentation and Communication Systems. He was awarded his Ph.D. in Digital Image Processing from Sri Venkateswara University, Andhra Pradesh. He is currently working as an Associate Professor in the Department of Electronics and Communication Engineering at Audisankara Deemed to be University. Dr. Sreenivasulu has a total of 22 years of teaching experience in the field of Electronics and Communication Engineering. He has published 26 research papers in international journals and 26 papers in national journals, reflecting his consistent contributions to academic research. His areas of research interest include Digital Image Processing, Computer Vision, Artificial Intelligence, Signal Processing, and UAV-based applications. His current work focuses on AI-enabled drone-based systems for real-time crop monitoring and precision agriculture.

Dr. G. Chenchu Krishnaiah obtained his B.Tech degree in Electronics and Communication Engineering from KSRM College of Engineering, Kadapa, A.P, India, and Master of Engineering (ME) degree in Applied Electronics (AE) from Sathyabhama University, Chennai, India. He earned his Ph.D. degree (Wavelet based image compression) in ECE Department from JNT University, Anantapur, A.P, India. Presently he is working as a Professor & Vice Principal at Audisankara College of Engineering & Technology (AUTONOMOUS), Gudur - 524101, Tirupati (Dist), A.P, India. His area of research interest includes wavelet transforms, Digital Image Processing, compression and denoising algorithms, Digital Signal Processing, Embedded Systems, VLSI Design, and VHDL Coding. He is a life member of ISTE (India), IAENG, SDIWC. He has 25 years of experience in Teaching & Research and he has guided 2 Ph.D.s.

Shaik Moula obtained his B.Tech degree in Electronics and Communication Engineering from Audisankara College of Engineering & Technology (AUTONOMOUS), Gudur - 524101, Tirupati (Dist) A.P, India, and M.Tech degree in Embedded Systems from Audisankara College of Engineering & Technology (AUTONOMOUS), Gudur - 524101, Tirupati (Dist) A.P, India. Presently he is working as Assistant Professor at Audisankara College of Engineering & Technology (AUTONOMOUS), Gudur - 524101, Tirupati (Dist), A.P, India. His area of research interest includes Digital Image Processing, compression, Digital Signal Processing, and Embedded Systems. He has 13 years of experience in Teaching.