REVIEW ON COMPREHENSIVE SYSTEM FOR ACCIDENT PREVENTION USING DETECTION OF DRIVER DROWSINESS AND ON ROAD OBSTACLE

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ABSTRACT

This project presents an integrated approach to ensure both driver safety and road obstacle detection using Artificial Intelligence and IoT technologies. An ESP32 Microcontroller-based AI system equipped with a camera continuously monitors the driver's eyes to detect signs of fatigue or drowsiness. Computer vision algorithms such as OpenCV and Mediapipe analyze real-time eye closure patterns, triggering alerts if the driver's eyes remain closed beyond a safe threshold. Simultaneously, ultrasonic sensors are deployed to detect obstacles or animals on highways. If any kind of obstacle is detected, the relay mechanism automatically halts the vehicle to prevent accidents. This dual-purpose system addresses two pressing challenges in modern transport—driver fatigue and animal fatalities on roads. By combining AI-powered drowsiness detection with IoT-based road obstacle detection, the proposed system enhances overall highway safety, minimizes roadkill incidents, and ensures responsible driving practices. Its low-cost implementation on ESP32 Microcontroller makes it feasible for large-scale adoption in both developed and developing countries. Ultimately, the system aims to create safer highways that respect both human life and ecological balance.

KEYWORDS- Artificial Intelligence, IoT, ESP32, AI, OpenCV, Mediapipe.

INTRODUCTION

Road transport plays a crucial role in economic growth and mobility, but it also brings significant risks to human and animal life. Every year, thousands of accidents occur due to driver drowsiness, fatigue, and collisions with animals crossing highways. Traditional safety systems like seatbelts and airbags protect drivers only after accidents occur; however, there is a pressing need for proactive safety systems that prevent accidents altogether.

One of the most dangerous yet preventable causes of accidents is driver drowsiness. Long-distance truck drivers, cab operators, and even private vehicle owners often experience fatigue during late-night driving. According to studies, drowsy driving reduces reaction times, impairs decision-making, and can be as dangerous as driving under the influence of alcohol. Existing solutions like lane departure warnings or cruise control systems are not always effective, particularly in rural or semi-urban highways. Hence, there is a need for a real-time driver monitoring system capable of detecting fatigue before it leads to an accident. Another major challenge is the increasing number of animal-vehicle collisions. Highways passing through forests and rural areas frequently witness accidents involving cattle, dogs, and wild animals like deer. Such incidents not only cause vehicle damage but also result in the loss of human and animal lives. Despite road signs and preventive measures, animal fatalities remain high because drivers often fail to notice animals in time.

This project addresses both challenges by designing an integrated safety system powered by Artificial Intelligence and IoT. The system uses ESP32, camera, and computer vision algorithms to detect driver drowsiness in real time. If the driver's eyes remain closed beyond a safe threshold, a visual or audio alert notifies them to regain attention. Parallelly, ultrasonic sensors are deployed to detect nearby obstacles or animals. If an obstacle is detected in the vehicle's path, the relay mechanism cuts off motor power, preventing collisions.

The project is significant for multiple reasons. First, it promotes safer driving habits by alerting drivers before fatigue causes harm. Second, it provides a cost-effective solution using readily available hardware like ESP32, sensors, and Python-based AI models. Unlike high-end commercial driver assistance systems, this solution is affordable, scalable, and adaptable to local conditions.

LITERATURE REVIEW

1. Kamran, M. Ahmad, et al., This study comprehensively summarizes all aspects of the drowsy state and its effects during car driving: its symptoms, causes, preventive actions, car accident statistics, sleep stages, and the behavioral, physiological and neural activation changes occurring during wakefulness and in the drowsy state. It considers drivers' behavioral data and corresponding methodologies for its analysis, the biomedical signals of the human body (including neuronal signals in the forms of electrical and hemodynamic responses), and their use for drowsiness detection. All of the existing methodologies, their uses and pros and cons, are comprehensively summarized.
2. Khan, M. Adil, et al., This paper proposes an end-to-end non-intrusive IoT-based automated framework to monitor driver behaviors, designed specifically for logistic and public transport applications. It consists of an embedded system, edge computing and cloud computing modules, and a mobile phone application, in an attempt to provide a holistic unified solution for drowsiness detection, monitoring, as well as evaluation of drivers. Drowsiness detection is based on detecting sleeping, yawning, and distraction behaviors using an image processing-based technique. To minimize the effects of latency, throughput, and packet losses, edge computing is performed using commercial off-the-shelf embedded boards. Moreover, a cloud-hosted real-time database for remote monitoring on an interactive Android mobile application has been set up, where admin can add multiple drivers to get drowsiness notifications along with other useful related information for driver evaluation.
3. Sikander, Gulbadan, et al., This paper presents a state-of-the-art review of recent advancement in the field of driver fatigue detection. Methods are categorized into five groups, i.e., subjective reporting, driver biological features, driver physical features, vehicular features while driving, and hybrid features depending on the features used for driver fatigue detection. Various approaches have been compared for fatigue detection, and areas open for improvements are deduced.
4. Hossan, Alamgir, et al., In this paper, we proposed and verified an EEG based system which not only alerts the driver by alarm, but also puts the vehicle in semiautomatic parking mode by controlling fuel supply if drowsiness is detected. At the same time, it reports nearby police stations by SMS which contains necessary information to take essential steps locating the vehicle. Stored EEG signals, obtained with wireless wearable headsets from numerous subjects in different conditions by different research groups, were used in this work. Power spectrum analyses were carried out in MATLAB to determine the dominant frequency components in the brain signals. The slow wave to fast wave ratios of EEG activities were assessed for a number of epochs to determine driver's drowsiness.
5. Banavathu, Sivaramakrishna, et al., The proposed solution involves a precise driver drowsiness detection system coupled with a multi-modal alert system. Upon detecting signs of drowsiness, the system employs nuanced alert mechanisms, such as controlled subtle jerks, to prompt the driver to regain alertness. Additionally, a red-light warning is projected onto the driver's face to counteract drowsiness effectively. Notably, instead of employing abrupt braking, our system adopts a gradual deceleration strategy to ensure a smoother and safer response, minimizing the risk of sudden movements and potential collisions with the windshield. Furthermore, the integration of cruise control mechanisms contributes to reducing the overall fatality rate.
6. Ganesh, Katta, et al., This paper presents a novel approach to address these challenges by introducing a driver safety system aimed at promoting good driving etiquette and mitigating distractions and fatigue. Leveraging Raspberry Pi and computer vision techniques, the system monitors driver behavior in real-time, including head position, eye blinks, mouth opening and closing, hand position, and internal audio levels to detect signs of distraction and drowsiness. The system operates in both passive and active modes, providing alerts and alarms to the driver while also implementing a negative reinforcement mechanism. Through a negative reinforcement system which consists of not starting the car if the driver is distracted and sleepy in the previous trip, he discourages distracted or drowsy driving behavior. Various methods for detecting drowsiness have been experimented with. The ones with the highest accuracy were used in the system.
7. Dhanalakshmi, P., et al., In this paper, the process includes OpenCV and a deep learning model that helps in detecting face and eyes using 68 face landmarks. If a person is drowsy then we will alert a person with the help of an alarm and we will send mails to their family or friends that the person is drowsy and inform them to kindly alert him, otherwise accidents may occur. The further development which we would like to do is to integrate a chatbot and that helps in keeping the person alert all the time. The current model will have good accuracy and developments to get rid of accidents. The last purpose is to beautify avenue safety and mitigate

injuries due to driving force drowsiness, contributing to the general nicely-being of society. The ultimate goal is to enhance road safety and mitigate accidents caused by driver drowsiness, contributing to overall well-being of society.

8. Alshaqaqi, Belal, et al., In this paper, a module for Advanced Driver Assistance System (ADAS) is presented to reduce the number of accidents due to drivers fatigue and hence increase the transportation safety; this system deals with automatic driver drowsiness detection based on visual information and Artificial Intelligence. We propose an algorithm to locate, track, and analyze both the drivers face and eyes to measure PERCLOS, a scientifically supported measure of drowsiness associated with slow eye closure.

9. Saini, Vandna, et al., The author stated that studies show that around one quarter of all serious motorway accidents are attributable to sleepy drivers in need of a rest, meaning that drowsiness causes more road accidents than drink-driving. Attention assist can warn of inattentiveness and drowsiness in an extended speed range and notify drivers of their current state of fatigue and the driving time since the last break, offers adjustable sensitivity and, if a warning is emitted, indicates nearby service areas in the COMAND navigation system.

10. Albadawi, Yaman, et al., This paper presents an up-to-date review of the driver drowsiness detection systems implemented over the last decade. The paper illustrates and reviews recent systems using different measures to track and detect drowsiness. Each system falls under one of four possible categories, based on the information used. Each system presented in this paper is associated with a detailed description of the features, classification algorithms, and used datasets. In addition, an evaluation of these systems is presented, in terms of the final classification accuracy, sensitivity, and precision. Furthermore, the paper highlights the recent challenges in the area of driver drowsiness detection, discusses the practicality and reliability of each of the four system types, and presents some of the future trends in the field.

METHODOLOGY

The proposed system integrates Artificial Intelligence and IoT to create a dual-purpose safety framework for highways. It comprises two main modules: driver drowsiness detection and road obstacle detection.

1]Driver Monitoring Module

An ESP32 Microcontroller connected to a USB or PiCam continuously captures real-time images of the driver's face. Using Python-based computer vision libraries like OpenCV and Mediapipe, the system tracks eye movements and blinking patterns. If the eyes remain closed for more than 2 seconds, the system does not intervene. However, if eye closure extends beyond 5 seconds, it triggers a drowsiness alert by displaying a popup or notification on the connected screen. This ensures the driver is made aware of fatigue before an accident occurs.

2] Road Obstacle Detection Module

An ultrasonic sensor is mounted on the vehicle to detect objects ahead. If an object is detected within a specified range, the system activates a relay switch to cut off motor power, bringing the vehicle to a halt. This prevents accidents caused by sudden animal crossings.

Both modules are powered by the ESP32 Microcontroller, making the system compact and cost-effective. The integration of AI for facial recognition and IoT sensors for obstacle detection provides a robust hybrid solution. The system is designed to be scalable for personal cars, commercial trucks, and public transport vehicles.

The proposed system ensures highways are not only safer for humans but also more sustainable for the environment.

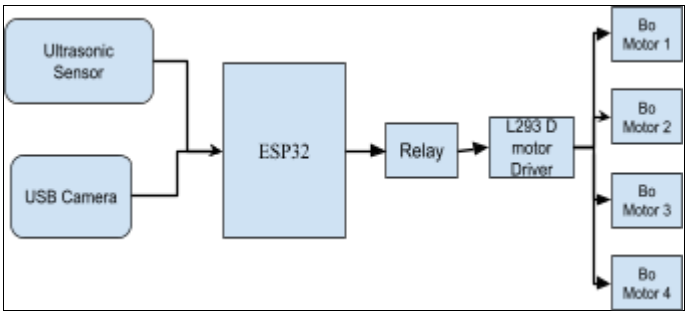

Fig.1:Block diagram of Proposed System

In this block diagram, an ESP32 is used as a microcontroller. The input devices consist of Ultrasonic Sensor & USB Camera. The output devices are Relay, L293D Motor Driver & 4 BO Motors. Both the input & output devices are connected to ESP32 Microcontroller.

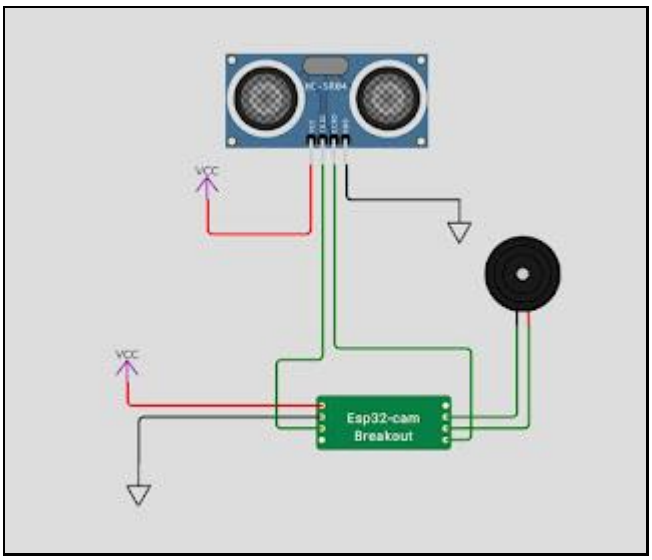

Fig. 2:Circuit Diagram of the Proposed System

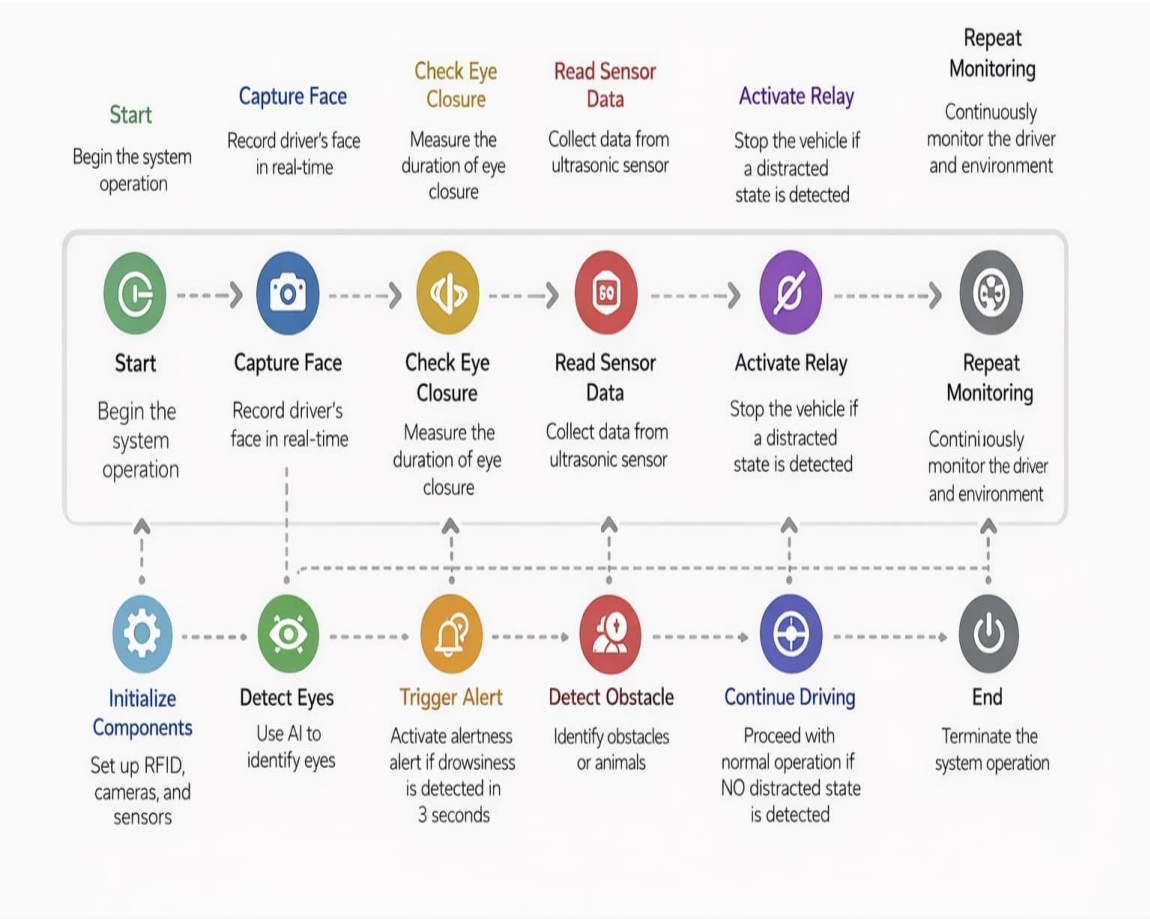

Fig. 3:Flowchart of the Proposed System

WORKING

The system begins with the setup of the ESP32 microcontroller, which acts as the main controller for the entire system. First, a USB camera is connected to the processing unit to capture real-time images of the driver. The camera feed is processed using Python programming with computer vision libraries such as OpenCV and Mediapipe to detect the driver's face and monitor eye movements and blinking patterns. The algorithm continuously analyzes the eye aspect ratio to determine whether the driver's eyes are open or closed. If the eyes remain closed for more than 5 seconds, the system identifies the condition as driver drowsiness and generates an alert notification on the connected display to warn the driver.

In the next step, the obstacle detection module is implemented by mounting an ultrasonic sensor at the front of the vehicle to detect obstacles on the road. The sensor continuously measures the distance between the vehicle and objects ahead and sends this data to the ESP32 controller. When an object is detected within the predefined range, the ESP32 processes the signal and activates a relay module connected to the motor circuit. The relay immediately cuts off the motor power supply, causing the vehicle to stop and preventing a potential collision.

Finally, both modules are integrated and tested together to ensure smooth operation. The ESP32 manages the inputs from the camera and ultrasonic sensor simultaneously, making the system compact, efficient, and reliable. Through this step-by-step implementation, the system effectively improves driver safety while also protecting obstacles on highways.

SYSTEM REQUIREMENT

HARDWARE REQUIREMENT

1] ESP32 Microcontroller
2] USB camera
3] Ultrasonic Sensor
4] Relay
5] BO motor*4
6] L293D Motor driver

SOFTWARE REQUIREMENT

1] Python Software IDE
2] VNCViewer
3] Raspberry Pi Imager

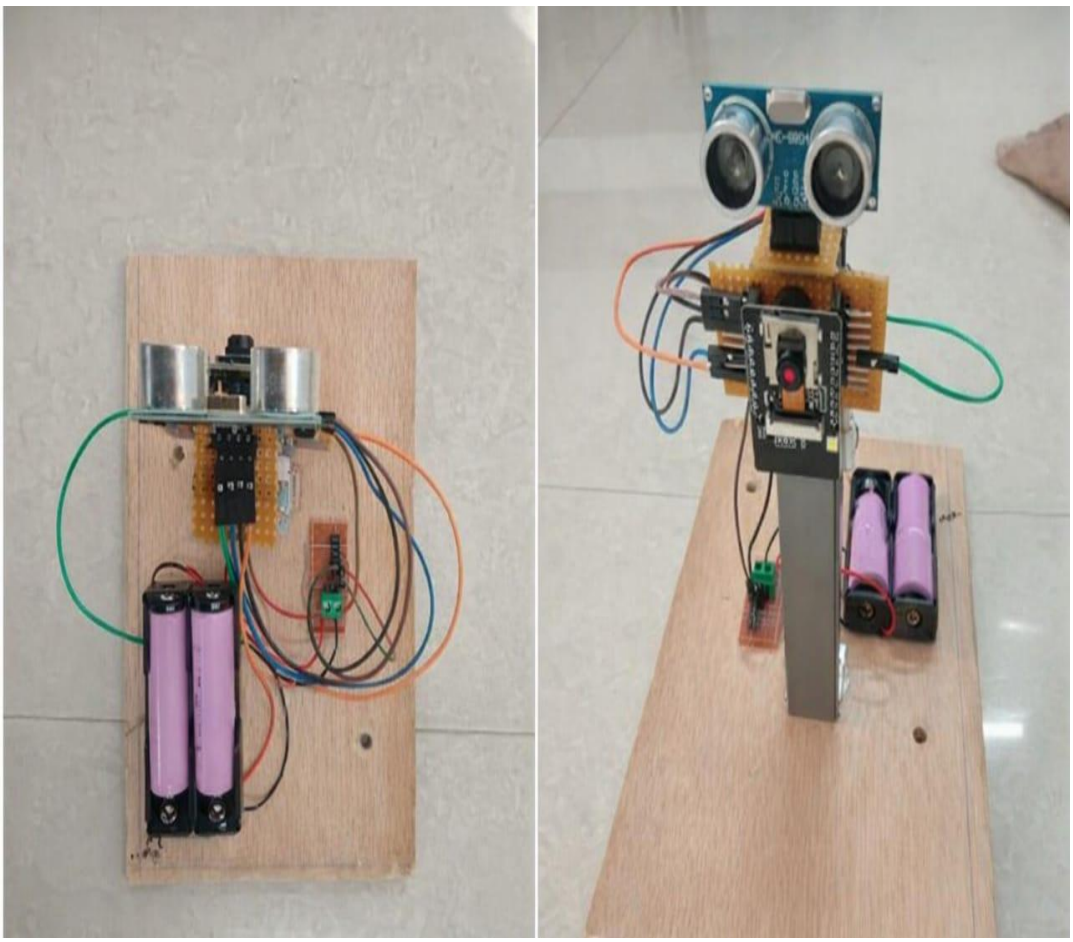

Fig. 4:Front & Top view of Experimental setup

Fig. 5:Output message that obstacle is ahead

The ultrasonic sensor detects if there is any object ahead and an 'obstacle ahead' message is generated.

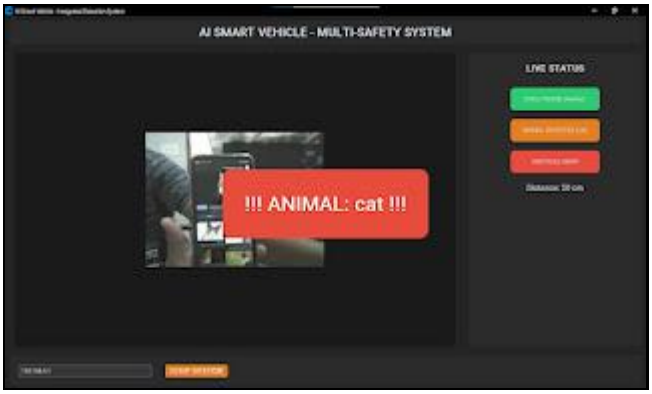

Fig. 6: Animal is detected

The face recognition technique is used to spot the animals. If any animal is detected then the message 'Animal' along with the name of animal is generated.

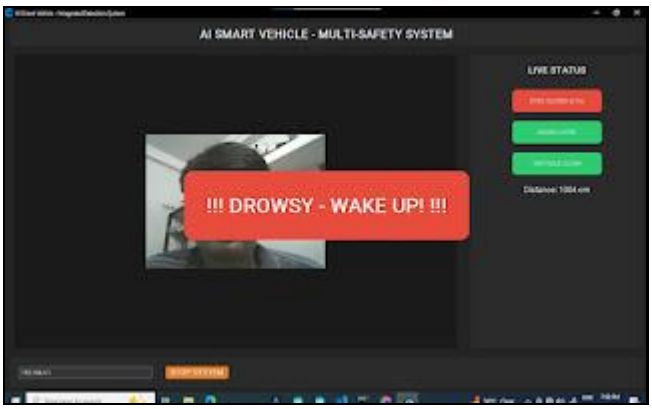

Fig. 7: Drivers drowsiness detected

The drowsiness alert is generated if drivers eyes remains closed for 5 seconds.

The implemented system successfully demonstrates the integration of Artificial Intelligence and IoT for improving highway safety through driver monitoring and road obstacle detection. The driver drowsiness detection module effectively monitored the driver's eye movements in real time using computer vision techniques. When the driver's eyes remained closed for more than 5 seconds, the system accurately generated a warning alert on the display, notifying the driver about fatigue. This helped in preventing potential accidents caused by drowsy driving.

CONCLUSION

The Harmony on Highways project presents an innovative solution to two critical issues: driver drowsiness and animal collisions on highways. By integrating AI-based real-time monitoring with IoT-enabled obstacle detection, the system prevents accidents proactively rather than reactively. Its low-cost implementation on ESP32 Microcontroller makes it accessible to a wide range of users. Beyond enhancing driver safety, the system contributes to road obstacle detection, ensuring ecological harmony alongside technological progress. This project demonstrates that safety and sustainability can coexist, setting the stage for smarter highways that protect both human life and the natural environment.

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