International Journal of Advanced Research and Review

www.ijarr.org

AI-Powered Edge Vision Traffic Management Platform for Real Time Monitoring and Congestion Reduction

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Abstract— Drowsiness and fatigue are among the top factors that are considered to contribute to car accidents, causing 1.3 million deaths per year. By using facial landmark identification, the Advanced Drowsiness identification System is able to accomplish its goal of lowering the total number of road accidents caused by various forms of driver weariness and falling asleep behind the wheel. Using a facial recognition algorithm, this system is able to identify signs of sleepiness in a picture. It detects and tracks the driver's face and eyes to compute the Eye Aspect Ratio (EAR), a validated measure for drowsiness detection. This system reduces fatalities and improves road safety by detecting driver drowsiness using Driving Behaviour Analysis (DBA). The goal of this technology is to make transportation safer by reducing the likelihood of driving errors caused by driver sleepiness.

The following terms are associated with this article: EAR, Raspberry Pi, Eye Detection, and Driving Behavior Analysis.

I. INTRODUCTION

Many car accidents in the US are caused by drivers who are fatigued, which is a very risky behavior. A third of all automobile accidents involving exhaustion happened in 2017, according to the National Highway Traffic Safety Administration (NHTSA). Drowsiness was a contributing factor in 91,000 incidents, which resulted in 7,500 injuries and 200 fatalities. Because the reasoning behind the judgments is unclear, these data do not do justice to the seriousness of sleepy driving.

Your risk of being involved in a car accident increases significantly if you microsleep while you sleep-drive. Microsleeps increase the risk of a catastrophic accident because drivers may lose control and crash. Driving while nodding off is not the same as having the impact of sleep on one's consciousness, which drains one's vitality, thinking capability, and capacity to make decisions. Results from the reported research show that: Psychological harm, such as BAC or Impaired, is worsened by prolonged awake [1]. While some solutions are more short-term fixes that boost compliance, others are more long-term treatments that try to lessen the impact of the problem and help people sleep better [2]. Also, make sure you don't nap while you're at work, turn off all electronics at least an hour before bed, avoid bright lights, noise, and uncomfortable mattresses to ensure a good night's sleep. It manages the length and quality of the bed and gets rid of bad traits like daytime drowsiness or driving weariness [3]. Maintaining and reducing a regular sleep pattern, avoiding electronic devices in the hours leading up to bedtime, and ensuring a comfortable mattress are all essential components of a healthy dream, which is crucial in the fight against sleepy driving. People are less prone to experience daytime drowsiness or driver fatigue if they maintain appropriate hygiene habits, which in turn improves the duration and quality of their sleep. It is possible to reduce drivers' tiredness by learning when individuals have sleep issues and by studying sleep disorders. If people suspect that

anything is causing them to feel drowsy at night or fatigued during the day, they should see a healthcare professional. There are techniques to check for this. In order to diagnose sleep problems and choose the best course of therapy, a circadian rhythm evaluation is helpful. Public education and awareness campaigns about the risks of overexertion are two important preventative interventions that might help reduce cases of sleepy driving. One way to manage other individuals in the transportation regions is to use employer relaxation and incentives. Changes to the time of usage, prohibitions against commercial drivers operating their vehicles continuously, and mandates that employers guarantee the safety of their workers are all examples of legal measures that may be taken to reduce the hazards associated with sleepy use. Identifying sleepy driving behavior and alerting drivers to rest may be achieved via the use of algorithms that can be implemented using feasible technology and mitigate the effects of music on tiredness detection [4]. Everyone needs to get enough sleep, see a doctor if you have trouble falling asleep, and take measures to prevent the consequences of driving after a few hours of sleep if we want to see an end to drowsy driving campaigns.

II. LITERATURE SURVEY

Using the networking architecture in current vehicles and sophisticated sensors, Intelligent Transportation Systems (ITS) can collect a massive quantity of real-time data about motors and drivers, completely transforming the way cars are analyzed [5]. With this deluge of data, driving behaviour analysis (DBA) is ripe for the picking. Improving street security relies heavily on using behavior to detect drivers' inattention or intoxication, volatility profiles, and fuel efficiency. To solve all of DBA's problems, nevertheless, such as the want for different types of records, analytical demonstrations, and modeling approaches, one must perceive it [6]. Research methods in database administration (DBA) include classifying research according to data types, analytical objectives, and modeling approaches. In order to study drivers' habits, scientists use a wide variety of data sources, such as in-car sensors, voice-activated networks, and external record streams [7]. Researchers may also use software that employs sophisticated modeling methods, machine learning, and statistical analysis to glean meaningful information from otherwise complicated datasets.

In addition, new methods for identifying and reducing the severity of street injuries are being investigated by researchers. The spatial and temporal volume of congestion due to accidents may be estimated with the use of fragility models, which provide valuable insights for the regulation of site visits and emergency response [8]. Accidents may be actively mitigated with the use of Bayesian change detection algorithms, which provide near-real-time accident detection capabilities. To further improve road safety, decrease injuries, and avoid accidents, we may integrate data from several sensors and use advanced signal processing techniques to build better early warning systems and collision avoidance structures [9]. In addition, advancements in vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication technologies enable continuous and environmentally friendly data exchange among vehicles, roadside devices, and cloud servers.

Protecting and ensuring the integrity of accident-related data conveyed inside intelligent transportation systems (ITS) is the goal of authentication mechanisms provided by blockchain technology [10]. In order to make road safety measures more successful overall, researchers may use blockchain technology to make accident detection and reporting systems more trustworthy and reliable. Problems persist even if DBA and accident detection approaches have made encouraging strides forward.

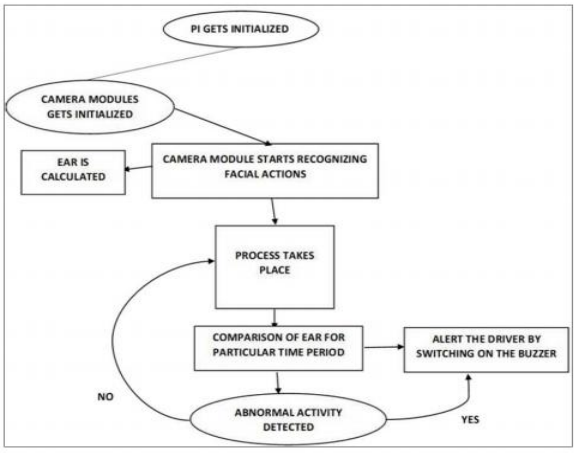
The widespread implementation of specific methods for real-time applications is hindered by their computing overheads, accuracy constraints, and complicated device designs. In addition, academics and practitioners in the field face enormous challenges due to the heterogeneous data and the merging of different records resources. To ensure the appropriate implementation of DBA systems and the development of trustworthy technologies for accident detection, it is necessary to address moral, privacy, and regulatory considerations [11]. Furthermore, there is great promise for improving the accuracy and performance of riding behavior analysis and coincidence detection systems by the integration of AI-related structures with machine learning (ML). Injuries may be better prevented with the capacity to manipulate datasets using ML approaches, which will allow for the detection of styles, abnormalities, and the development of riding behaviors. Researchers may create more comprehensive predictive models that react to ability concerns and eliminate them in real-time [12], all while instructor’s train algorithms in various driving scenarios and behavior. Academic institutions, businesses, and authority organizations must work together interdisciplinarity to study and build systems for analyzing driving behaviors and a new take on facial recognition. The rapid sharing, development, and adoption of improved statistical data, materials, and, most crucially, knowledge may be facilitated by such collaborative endeavors [13]. Furthermore, stakeholder engagement may aid in the development of reference models, methodologies, and criteria for evaluating the efficacy and competence of DBA structures cross domains and regions. Overall, the safety of the avenue and the impact of

accidents may be greatly reduced with the use of analytical words that focus on riding behavior and accident detection. We can get better understanding of the driving force and develop new systems that are suggestive of effectively reducing the twist of fate fee by exploring complex technological advancements such as sickness sensing, verbal exchange structures, and data analytics [14]. So that the major transport infrastructures of the future are better maintained and more efficient, we will continue to increase research and development in this field in order to map out such a diverse future.

III. SYSTEM DESIGN AND METHODOLOGY

The system's methodology is based on configuring the whole computer using a Raspberry Pi. The initialization process kicks off the series of actions by activating the Raspberry Pi. First, it starts taking pictures of the driver's face by activating the camera module. A series of processing procedures are applied to this collected picture in order to detect, adjust, and evaluate the driver's eyes and face.
A scientifically verified measure for detecting sleepiness, the Eye Aspect Ratio (EAR) is the primary indicator of awareness, particularly when sluggish eye closure, a frequent indication of exhaustion, is detected. The system then checks the recordings for any strange activity that would indicate the driver is sleepy once the images have been processed. The system has an alarm mechanism that, when activated, notifies the driver of the approaching danger by sounding a buzzer. In the meantime, the system steps in to help the car run by adjusting the speed using the accelerometer. To improve transportation safety, it automatically reduces the vehicle's speed to reduce the likelihood of accidents caused by tired drivers. The Driver Drowsiness Dataset (DDD) is a collection of extracted and cropped driver faces used to train the algorithm. With 41,790 photos total, the dataset may be divided into two categories: drowsy and non-drowsy.

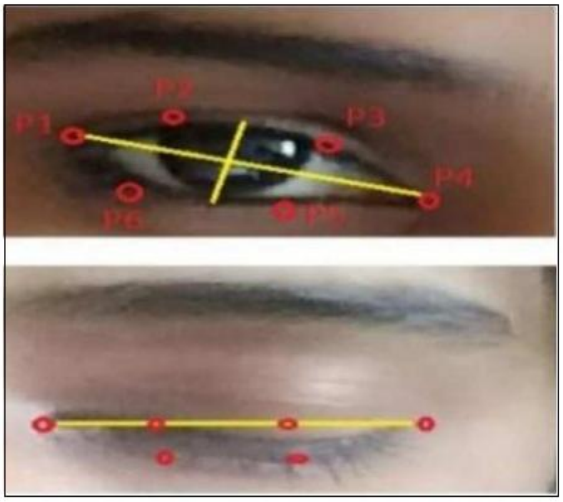
Figure 1. System Architecture Design



This technology utilizes artificial intelligence approaches to analyze visual data in an effort to tackle the crucial issue of tiredness.
The device is able to detect sleepiness in the driver in real-time by using an algorithm that can identify and track the driver's eye movements and facial characteristics. Saving lives and reducing traffic accidents, this sophisticated approach of combatting tiredness has the potential to have a big impact on road safety. The system may also provide drivers with the option to disable the automated acceleration management in certain scenarios. For instance, under some circumstances, they may decide to accelerate even more by using the accelerator. To provide drivers more leeway while still keeping them safe, this feature lets them manually bypass the system in certain scenarios. Future iterations of the system may also include adaptive algorithms that pick up on subtleties in driving style or user preferences. The technology adjusts the accelerator control in response to current and past driving habits and other factors using machine learning. This concept is designed to improve system efficiency, safety, and user experience by learning driving behavior. With this method, we now have an AI-based answer to the age-old issue of sleepy driving. The system's adaptive control mechanisms, real-time monitoring, and visual statistic processing make it possible to detect and mitigate the dangers of driver weariness. The efficiency of these systems has the potential to improve transportation safety for everyone involved, cut down on accidents, and save lives in the long term. Adding

a Raspberry Pi as the central processing unit further improves the system's efficiency. Because of its diminutive physical factor, low power consumption, and computing capabilities, the Raspberry Pi is a perfect platform for integrating AI algorithms and analyzing images in real-time. The system's adaptability to different automotive designs and environments is made possible by its mobility, which also allows for flexible connection with various types of sensors and peripherals. urthermore, the use of Raspberry Pi is based on an open-source environment, which facilitates the offering and seeking of help from other developers to continuously improve the system's functionalities and performances. By using a form predictor, the area around the eyes and face may be identified in the live video feed. Figure 2 shows the degree of sleepiness, which was calculated by taking the face landmark recognition characteristics and adding them to the pre-existing dataset, which was based on the geometric distance between the eyes (the eye aspect ratio). For every video clip, certain visual markers are noted. There is a calibrated ratio between the eye's breadth and height.

Figure 2. Eye Detection



Several video frames are used to calculate the Equivalent Average Rate (EAR) [15]. There is only one blink seen.

$$EAR = \frac{||P2-P6|| + ||P3-P5||}{2||P1-P4||} \quad (1)$$

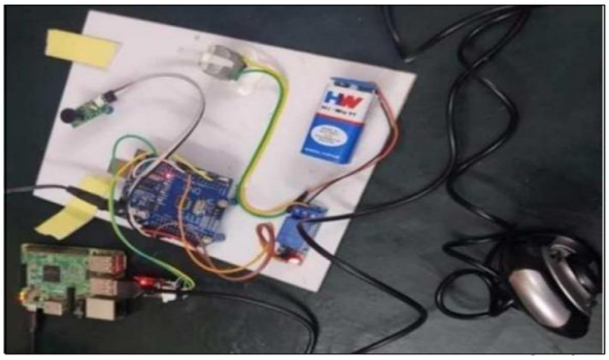
In Figure 2, the two-dimensional landmark location is denoted as P1,..., P6. When the eye is open, the Eye Aspect Ratio (EAR) is rather constant; when closed, it becomes near to zero. When the subject maintains eye contact with the camera, the EAR stays within the normal range. The EAR drops dramatically when the driver shuts their eyes for an extended period of time; a low value indicates sleepiness.

Figure 3. Raspberry Pi

As far as low-cost computer solutions go, the Raspberry Pi 3 Model B is where it's at. The understated elegance of this little but potent gadget challenges norms. The Raspberry Pi stands out from the crowd—an unadorned, credit card-sized circuit board—instead of a stylish casing, much like a regular computer.

This seemingly little exterior conceals a plethora of computer power inside its small housing, which limits the tool's actual usefulness. The Raspberry Pi, which looks like a motherboard, exposes its setup chips and ports in a manner similar to the internal circuitry seen in a standard computer. Nevertheless, the exceptional multi-functionality of Raspberry Pi is what truly sets it different. It offers all the essential components needed to attach input/output devices and storage units, allowing users to immerse themselves in the computing arena without any limitations. Furthermore, Raspberry Pi is adaptable and has a simple design, so it can be used by anyone with varying degrees of expertise. It seems to be the greatest option for expanding computer activities in low-income areas where connection to the internet may be scarce or expensive because to its cheap cost and little resource requirements. When it comes to STEM education, Raspberry Pi offers a scalable computing platform that is both accessible and ideal. Webcams are small video cameras that may transmit live video or still images to a computer network, which can include the Internet. A camera may be built into hardware, attached to a display, or placed on a desk; they are often tiny and flexible. Therefore, the Raspberry Pi is more than just a piece of hardware; it is an affordable and flexible platform for computing. The Raspberry Pi revolutionized computers and knowledge because of its small size, tremendous capabilities, and inexpensive price. Raspberry Pi is revolutionizing education, providing a platform for concept testing, and empowering individuals worldwide. It is shattering barriers and opening doors to new possibilities in the ever-changing world of technology.

Figure 5. Complete Hardware Kit



If we want to create a society where everyone has access to better chances and where people are competent in the technologies of the future, the Raspberry Pi should be our compass. Live audio and video chatting sessions are made possible by these, and they often use compressed codecs to make streaming more efficient. Webcams are useful for a variety of purposes despite having lower resolution than handheld video cameras. In Fig. 5, you can see the whole hardware package of the project.

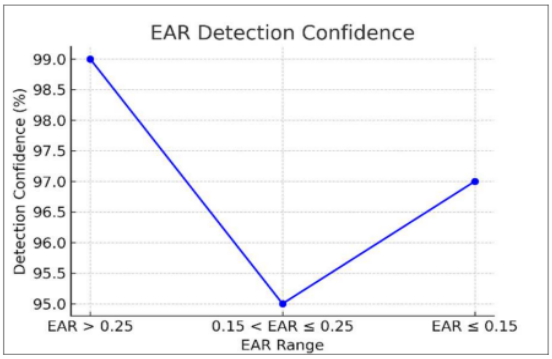
IV. RESULT AND DISCUSSIONS

Most traffic accidents are caused by sleepy drivers; a new device called Advanced Drowsiness Detection device (ADDS) aims to combat this problem. With the Raspberry Pi as the controller, it's used by face detection and EAR analysis of drivers to evaluate their level of tiredness. In order to recognize a driver's face and avoid false positives caused by environmental factors like light and noise, the Haar Cascade algorithm is used. Eye closure rates are defined by the system using EAR values, which indicate the likelihood of sleepiness. If the system detects that the driver is becoming too sleepy to operate the vehicle safely, it will alert them with a beep tone and turn off the vehicle's controls.

TABLE I. EAR Analysis Table

EAR Range	Driver State	Action Taken	Detection Confidence (%)
EAR > 0.25	Alert	No action	99%
0.15 < EAR ≤ 0.25	Drowsy (Mild)	Audio Alert	95%
EAR ≤ 0.15	Drowsy (Severe)	Vehicle Speed Modulation	97%

Figure 6. Graph for EAR Detection Confidence



You can observe how the EAR value impacts the driver's drowsiness from table I and figure 6. Given the present state of the road, an accelerometer is included to record the vehicle's movements and provide the ADDS with real-time input. Fast and efficient emergency management is possible because to this data's real-time connection with other systems, which provides access to fleet managers or emergency response teams. In order to evaluate driving behavior and share data, the ADDS connects to cloud-based services. Thanks to this feature, the ADDS will play a crucial role in facilitating advancements in vehicle safety in the future. The addition of machine learning (ML) has the ability to significantly enhance the system's performance and anomaly detection capabilities by analyzing massive datasets derived from real-life instances. Table II shows the time required at each level of the model to identify tiredness. The suggested model processes the data and triggers the alarm in about 110 milliseconds if the driver is determined to be sleepy.

TABLE II. Real-Time Detection Latency Table

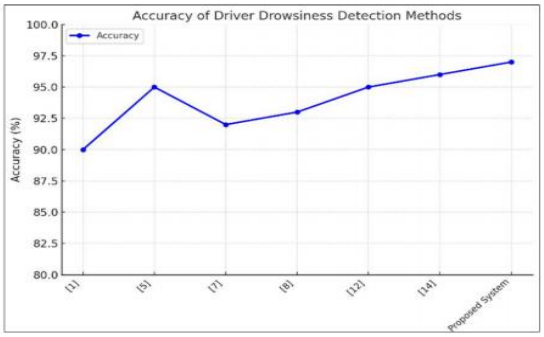
Stage	Processing Time (ms)	Cumulative Time (ms)
Image Capture	20	20
Facial Landmark Detection	50	70
EAR Calculation	30	100
Alert Trigger	10	110

In comparison to older systems, the ADDS is better in terms of design, affordability, and scalability. It is easy to incorporate into many situations because to its portable nature and ability to work in diverse settings. An important step toward bettering driver and passenger safety, the ADDS has a 97% detection rate and can intervene in real-time. Thus, the ADDS exemplifies how cars may have a tangible impact on road safety via the use of algorithms and technology, integrating the analysis of real-time data to address the dangers caused by driver weariness. Another reason to consider it a progressive innovation in the Automotive Safety environment is its intrinsic quality of being designed as a dynamic and changing solution based on big data analytics. The suggested model outperforms the already known market models, as shown in Table III and Figure 7. Many traffic accidents may be avoided with this technique.

TABLE III. Comparison Table

Ref. No.	Models/ Methods	Accuracy (%)
[1]	Facial motion entropy	90
[7]	Convolutional Neural Networks	95
[8]	AI-based multimodal fusion	92
[9]	Combines visual and physiological features	93
[11]	Efficient face descriptors	95
[14]	Machine learning algorithm	96
Proposed Work	**EAR metrics**	**97**

Figure 7. Graph for comparison of Existing and Proposed work



V.CONCLUSION

By using facial recognition and the Haar Cascade algorithm, this system seeks to enhance road safety by detecting and notifying sleepy drivers in real-time. The technology employs a digital camera to examine video frames in real-time, detecting tiredness in drivers by analyzing face shapes and eye area. A wide range of vehicles, including commercial trucks, private automobiles, and even public transit systems, may benefit from the sleepy driver warning system's adaptability and portability. It is readily linked into driver monitoring programs and fleet management solutions, and its modular architecture guarantees compatibility with current automobile safety systems. This system enhances vehicle and road safety by detecting and preventing driver sleepiness via the use of face and eye recognition technology, real-time monitoring, and complex algorithms. Alarming the driver anytime he feels tired, this innovative technique seeks to prevent accidents connected to drowsy driving and make the world a better place. There will be fewer accidents caused by sleepy drivers because to the system's special capacity to make roads and vehicles safer.

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