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Real-Time Driver Drowsiness Detection System Using Eye Blink Analysis and WhatsApp Alert Integration

Purimitla Ramalingamma[1], P Venkateswarlu[2], K Meghana[3], B Mahammad Hameed[4], CH Vasanthi[5], V Vignesh[6]

[1, 2] *Assistant Professor, Department of Artificial Intelligence & Data Science, PACE Institute of Technologies and Sciences, Ongole, India*

[3, 4,5, 6] *Student, Department of Artificial Intelligence & Data Science, PACE Institute of Technologies and Sciences, Ongole, India*

Abstract:- Driver drowsiness is a common yet under-reported contributing factor to road traffic accidents, since diminished alertness reduces attention to primary tasks, in turn affecting response time and the decision making process. This paper proposes a computer vision and artificial intelligence-based smart real-time model to detect driver drowsiness. The use of a webcam captures a view of the driver, and OpenCV's implementation of HaarCascade Classifier detects and tracks eye movement. Early fatigue can be detected with the blink count and duration. When the driver has their eyes closed for more than 2 seconds, an automated alert is sent to the driver, vehicle owner, and emergency contacts using the Twilio WhatsApp API. While solutions such as Drowsy Driving Detection already exist, the proposed technique is vision-based, low-cost, and could be deployed in any vehicle. It also continuously records blink activity for behavioural experiments, and it shows effectiveness and consistency in a variety of light and face orientations. This shows how AI-driven computer vision combined with real-time communication can directly make road safety-improving interventions, particularly to reduce accident risk due to fatigue.

Keywords*: Driver Drowsiness Detection, Eye Blink Analysis, Computer Vision, OpenCV, HaarCascade Classifier, Real-Time Monitoring, WhatsApp Alert System, Artificial Intelligence, Deep Learning, Road Safety***.**

1. Introduction

Driver sleepiness, which is when your eyelids get heavy after being on the road for a long time, is still one of the main causes of crashes. There are still a lot of problems with road safety around the world. The World Health Organization and the National Highway Traffic Safety Administration have both done studies that show that almost one in four deadly crashes happen when a driver falls asleep at the wheel. Most traditional systems for finding fatigue use physiological sensors like EEG and EOG. They are functional but they're big and uncomfortable, so you wouldn't want to wear them on your head all day. Indirect methods like tracking steering habits or analyzing lane drift only work when the wheel barely moves or the road is straight and boring under a gray sky. With recent improvements in AI and computer vision, we can now make hidden camera systems that watch how alert a driver is in real time [17]. They can, for instance, catch the quick flutter of eyes that are about to close. This study shows a new way to use OpenCV's, HaarCascade Classifier to watch a driver's eyes and count how many times they blink and how long they last. This can help you spot the first signs of tiredness, like when their heavy eyelids start to stay closed. If your eyes stay closed for more than two seconds, the system will think you're tired and send an alert that flashes brightly on the screen right away. The Twilio WhatsApp API is used by this project to send warning messages to the driver, owner, and passengers right away. This feature is fantastic. Just like when you glance at the dashboard, you receive a little buzz on your phone. People react instantly to this quick communication method, maybe with a flashing alert or a sharp buzz. This reduces the likelihood of mishaps caused by slow response times. It is inexpensive, easy to use, and compatible with a simple webcam. Like a clock, it records every blink minute by minute and second by second. Both intense sunshine and the soft light from a desk lamp are suitable for its operation. The proposed framework is a significant step toward creating truly intelligent transportation systems. A automobile could be aware of a red light, for example, before the driver even glances up. It makes use of IoT to communicate with objects in real time and AI to see them. Like headlights cutting through fog [3], it makes the road safer, smarter, and more connected by bringing people and technology together in real life [16].

2. Literature Review

To determine when a driver's eyelids begin to droop, professionals in this sector have worked very hard. Finding a strategy to prevent collisions brought on by fatigue and inattention is very difficult. The majority of the early studies in this field relied on physical signal analysis techniques, including muscle tension measurement, brain wave reading, and rapid eye movements. In 2001, Lal and Craig were among the first to measure brain activity associated with fatigue using EEG data. They found that the steady drift of tiredness was extremely comparable to variations in theta and alpha waves. Jap, Lal, and Fischer (2009) developed an electrooculogram (EOG) device that precisely recorded blink rate and eyelid movement in a quiet, well-lit laboratory [4]. Although these sensor-based techniques were quite effective, they still required electrodes to be adhered to the skin, which was painful and made it difficult to utilize them continuously while driving. Researchers examined both behavioral strategies and vehicle-based methods to overcome these issues. They observed how drivers responded to road shimmer caused by heat. Dinges and Grace created a gadget in 1998 to measure how drivers rotated their automobiles. Minor driving mistakes, such as a slight deviation at the lane boundary, might indicate if a motorist was drowsy. The strategy seemed to be successful, but it became less effective as the car traveled, the road curved, or the rain made the windshield cloudy. Because of this, employing it outside of the lab proved difficult. Systems that employ cameras to detect fatigue began to get increasing attention as computer vision technology advanced. These technologies might silently monitor indicators of fatigue with a simple look or blink. In 2001, Viola and Jones published the Haar Cascade Classifier. By making it quick enough to recognize faces and eyes in simple grayscale images—like identifying a profile in a dark picture—it revolutionized real-time object identification. Bergasa and his colleagues built on this notion by tightening the focus, making it seem like a lens snapping into place [3]. A face monitoring system that tracked people's eye closure durations in 2006 used the Percentage of Eye Closure (PERCLOS) statistic to ascertain whether or not they were sleepy. In 2006, scientists developed a gadget that could monitor people's facial expressions and calculate their level of fatigue from the length of time their eyelids were closed, using the Percentage of Eye Closure (PERCLOS) statistic. Building on this idea, Abtahi, Shirmohammadi, and colleagues (2014) created the Eye Aspect Ratio (EAR), a method that uses facial features to identify micro-sleep, including an abnormally lengthy blink. (2015) enhanced vision-based methods by integrating infrared imagery with facial feature analysis. This enhanced their ability to detect human drivers in low-light or nighttime conditions. Convolutional Neural Networks (CNNs) and other deep learning models have revolutionized the market thanks to AI.

Park and his colleagues developed a CNN-based system that could determine if a motorist was awake, yawning, or sleeping just by glancing at their face [2]. Even in tough situations, the system was very accurate. Researchers made vision-based methods better in 2015 by combining infrared imaging with facial feature analysis. When headlights barely lit the road, this made detection much more reliable. Deep learning models like Convolutional Neural Networks have come a long way in the field as artificial intelligence has grown. Abouelnaga and the team (2020) made hybrid models that mix computer vision with Internet of Things (IoT) connectivity. This lets fleet managers watch things from a distance and send data to each other.

Researchers made a CNN-based system in 2017 that could tell if a driver was awake, yawning [2], or asleep just by looking at their face. Even when there were shadows or glare, the system was very accurate. But deep learning models usually need powerful GPUs and huge datasets, which makes them hard to run on small, low-power devices, like a computer board that is quietly murmuring on a desk [9]. Deng et al. got to work on fixing these issues. In 2020, researchers created hybrid models that combine IoT connectivity with computer vision. This lets fleet managers watch vehicles from a distance and share information like tire pressure and fuel levels in real time [1].

3. Existing System and Proposed System

Wakefulness detection systems have improved a lot, but there are still some issues that keep them from completely stopping accidents caused by tired drivers. For example, the warning may arrive too late, as a blink after the wheels begin to wander toward the shoulder. Traditional approaches for detecting brain impulses and tiny eye muscle twitches include physiological sensors such as EEG and EOG devices. These approaches can detect early indications of fatigue correctly, but they are inconvenient and interfere with driving. It's like having a sensor rub against your skull every mile. Drivers must wear electrodes or headbands for these systems to function, therefore they cannot be utilized for daily driving. This is particularly true for lengthy travels or busy delivery routes when comfort is essential. Old methods monitor how you steer and how the vehicle moves to determine whether you're fatigued. They check for minor issues, such as drifting out of your lane, faulty brakes, or the wheel moving beneath your hands. These systems function well on test tracks, but on actual roads with curved lanes, high traffic, and slippery pavement, they may quickly get confused and flag things that aren't there. Early computer vision techniques employing basic motion tracking or static thresholds to detect eye closure were ineffective when lighting conditions altered, the driver rotated their head, or a pair of glasses reflected an unintended glare [5]. Most of the systems we have now couldn't send alerts in real time. Instead, they just kept track of when someone was tired, like writing down every yawn in a driver's report, instead of stepping in right away to stop problems. As a consequence, many old models grew too complex, sluggish, or just not quick enough to keep drivers safe, similar to a warning light that flashes just seconds too late. The proposed framework fixes these problems by using an intelligent, vision-based drowsiness detection system that combines OpenCV's Haar Cascade classifier with Twilio's WhatsApp notifications [13]. The moment a driver's eyelids begin to droop, this device will promptly alert you. Like a camera that focuses instantly when anything moves, its two-part design increases detection accuracy and accelerates reaction time. A live video feed of the driver's face is kept up to date by the first module. It may make use of the car's built-in camera, which can recognize every blink, or a regular webcam. The system examines each frame to identify the eyes, counts the number of times they blink, and determines how long they remain closed. For example, it can detect when the lids contact in a blink. If the system detects that your eyes are closed for more than two seconds, it assumes you are asleep. The second module then sends an alarm using the Twilio API, which immediately sends a WhatsApp message to the driver, car owner, and emergency contact. A brief chime announces the beginning of the dispatch. This method for providing real-time alerts is a significant advance over previous ones that just logged tiredness data and did not raise an alarm. The new design not only answers rapidly, but it is also intended to be inexpensive and simple to use. For example, consider a sensor that fits comfortably around the wrist and is reasonably priced. It simply requires a basic webcam and works with free software. You do not need any costly equipment or large sensors; just plug it in and go. The system is modular, so it may be used with any arrangement, including a laptop on a cluttered desk, a tiny embedded board, or a Raspberry Pi close to the display. It also records the number of blinks the driver makes every minute and second. For example, you may see a person's eyelids twitch slightly during the night shift to gauge their state of awareness. The ability to monitor fleet operations, assess driver conduct, and guarantee safety is a result of this. Our new model is perfect in every way: it's cheap, it works, and it's really quick to respond. It turns observation into action by integrating existing computer vision methods with new cloud communication technologies. In this way, problems may be foreseen and prevented. An important step forward in driver monitoring has been achieved by this technology. There has to be a concerted effort to keep roads safer, and this helps close the gap between the signs of fatigue and prompt action. For instance, it has the ability to identify a tired vehicle prior to wheel spin.

4. System Architecture and Workflow

The planned AI Eye-Based Drowsing Recognition and Alert System has a flexible and efficient design that tracks in real time by analyzing eye movements, processing the data, and sending alerts naturally, without the need for human monitoring. The framework's four main components are data collection, recognizing features, assessing drowsiness, and sending alerts. These layers are piled on top of each other, similar to pages on a silent server. Each portion has a unique purpose, yet they are interconnected to ensure accuracy, dependability, and speed.

When the system is in operation, for example, the gears fit together properly. The data collection layer is located at the bottom of the system. It employs a webcam or a tiny camera set near the dashboard to capture live footage of the driver's face. This layer is constantly active and transmits live footage to the next phase in the process. The technology transfers the collected frames to the next step, where they are converted to black and white photographs and cropped to highlight the area of interest, similar to clipping a picture to concentrate on a single bright doorway. These processes reduce noise in the computations and direct the system's attention to essential face characteristics, particularly around the eyes, where every little shift in light counts. Haar Cascade from OpenCV[3]. The classifier is the source of power for the feature extraction layer. This is a machine learning technology that can detect items after being trained on thousands of photos, both good and negative, such as faces that appear briefly in light and shadow. No matter how the light changes, how much of the face is obscured by a shadow, or how the head tilts, the classifier instantly locates the eyes in each picture. The areas of the eye that have been cut are where more research begins. This enables the system to monitor subtle changes that signify exhaustion, such a slower blink or a wandering look. The module starts monitoring in real time as soon as it recognizes the eye areas, much like a camera that records each slow blink. It calculates how long you keep your eyes closed and how often you blink. When you blink quickly in between pictures, for example, a counter records the number of frames the eyelids stay closed. It has several potential uses, such as a delivery van and a family car. The system logs every blink and appends a timestamp. In order to keep transportation operations safe, this gives you clear information that lets you know when someone is tired. To improve performance in low-light conditions, such a foggy night time road, infrared or thermal imaging may be included in future upgrades. Improved accuracy in finding items might also be achieved with the use of deep learning models like CNNs or Vision Transformers. Edge devices like a Raspberry Pi or an NVIDIA Jetson, when combined with visual data, a driver's heart rate, or grip pressure, may provide a smart and all-encompassing assistance system. If successful, this endeavor will mark a major advancement in the search for smarter, safer modes of transportation. As an example, consider cars that can sense when there will be an unexpected slippery patch and change lanes before the driver does. All of the layers work nicely with Python's. runtime, reducing effort while maintaining optimal performance. Standard desktop PCs, Raspberry Pi boards, and even embedded microprocessors all function admirably with the system. This opens up a wide range of potential applications, from passenger cars to delivery trucks cruising down the interstate at high speeds. The suggested design is a simple, powerful system that functions like parts fitting together, thanks to the integration of machine learning, precise data analysis, and fast internet connections. A clever, scalable approach to making cars safer, with a modular and adaptable architecture that can detect an abrupt swerve and respond instantly, for example.

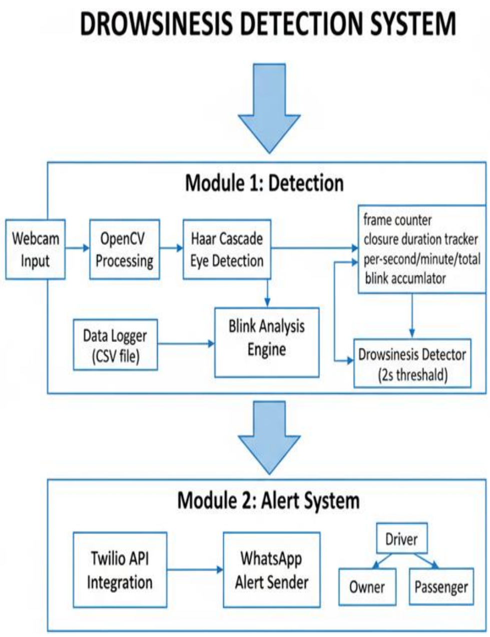

Figure 1. System Architecture and Workflow

5. Methodology and Implementation

Combining WhatsApp notifications with eye-blink analysis, the proposed 24/7 Driver Sleep Detection System is a perpetually accurate, lightning-fast, and pulsating monitoring gadget for drivers [6]. Powerful computer vision, analysis of real-time data, and automatic notification delivery are the means by which this is accomplished. All of the system's essential libraries, including OpenCV, pandas, and Twilio, are set up to work together like well-fitting code, and the system runs in the Python environment. An accurate machine learning model called OpenCV's Haar Cascade Classifier [11] is used in the identification procedure. It can recognize facial traits as precisely as capturing the curve of a grin. The ML system can quickly tell whether a person's eyes are open or closed after analyzing hundreds of faces. This is possible regardless of the angle of the camera or the brightness of the hallway lights.

5.1. Implementation

If a person's eyes are closed for more than two seconds, the automatic system concludes they are sleeping. This natural structure helps the system to discern between a quick, result-oriented blink and a longer, heavier eye peace of mind, which happens when you're tired and sleepy. It has several potential uses, such as a delivery van and a family car. The system logs every blink and appends a timestamp. In order to keep transportation operations safe, this gives you clear information that lets you know when someone is tired. To improve performance in low-light conditions, such a foggy night time road, infrared or thermal imaging may be included in future upgrades. Improved accuracy in finding items might also be achieved with the use of deep learning models like CNNs or Vision Transformers. Edge devices like a Raspberry Pi or an NVIDIA Jetson, when combined with visual data, a driver's heart rate, or grip pressure, may provide a smart and all-encompassing assistance system. If successful, this endeavor will mark a major advancement in the search for smarter, safer modes of transportation. As an example, consider cars that can sense when there will be an unexpected slippery patch and change lanes before the driver does. An empty Boolean flag is set and the Twilio REST API is promptly contacted when the algorithm detects indicators of fatigue, such drooping eyelids. A customized WhatsApp message with the subject line "Drowsiness detected!" may be sent to you by the system thanks to this API. It will appear on your screen in a vivid hue seemingly out of nowhere. Keep your eyes on the road and be prepared for any light or turn that may appear. Those on the alert list, including the driver and vehicle owner, will get this message promptly. Because alerts are given out instantly, teams can respond quickly to issues like a slippery patch. The warning system may also use the car's speakers to immediately disseminate information, in addition to emailing and texting. It has several potential uses, such as a delivery van and a family car. The system logs every blink and appends a timestamp. In order to keep transportation operations safe, this gives you clear information that lets you know when someone is tired. To improve performance in low-light conditions, such a foggy night time road, infrared or thermal imaging may be included in future upgrades. Improved accuracy in finding items might also be achieved with the use of deep learning models like CNNs[15] or Vision Transformers [8]. Edge devices like a Raspberry Pi or an NVIDIA Jetson, when combined with visual data, a driver's heart rate, or grip pressure, may provide a smart and all-encompassing assistance system. If successful, this endeavour will mark a major advancement in the search for smarter, safer modes of transportation. As an example, consider cars that can sense when there will be an unexpected slippery patch and change lanes before the driver does.

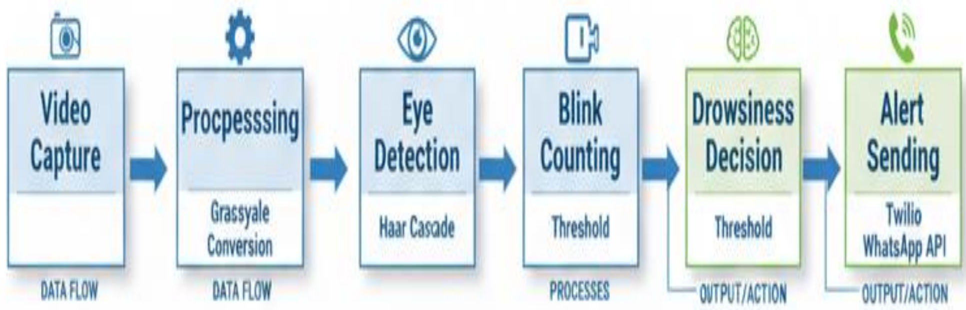

Figure 2: Work flow

6. Experimental Results and Analysis

A novel 24-hour automobile sleep monitoring system was tested in both peaceful lab conditions and busy roadways to assess its performance, responsiveness, and, most critically, its consistency in detecting when the driver is sleeping. The system uses eye-blink detection and WhatsApp messages. We tested it on people with different face shapes, when they blink, and under different lighting settings (from soft morning light to intense fluorescent glare) to make sure it would work in a lot of real-world situations. Driver awareness testing, a short drowsiness test that felt like a long blink, and a protracted eye closure method that felt like severe weariness were the three separate procedures that each participant had to go through [11]. Every session was filmed using a standard camera. You can see the driver's every eye movement on the footage. The eye detection method of Haar and Cascades was consistent regardless of the new conditions. It could discern between open and closed eyes in low light or when a person's shadow moved over their face [12]. Even when the user wore spectacles or made rapid head movements, the system continued to function normally. Each test collected blink data once every second, automatically sorted it by minute using the panda’s package, and then saved it to a CSV file. A steady pulse seemed to be pulsing across the screen as a result of this. Constant data tracking yielded a sizable dataset amenable to statistical and behavioural analysis in the future. Because of this, scientists were able to piece together the connection between fatigue and ocular motions like the gradual lowering of an eyelid [10]. The results showed that changes in blink rate are associated with the first signs of fatigue, such as drooping eyelids and a decrease in blink frequency. When drivers were fully conscious, they blinked continuously, closing their eyes quickly and often like a camera shutter. As they became tired, their blinking rate decreased. The lids remained closed for a bit longer, as if the eyes were attempting to stay open. The detection algorithm was updated to identify any eye closure that lasted more than two seconds, such as if someone blinked for just a heartbeat too long, as an indication of tiredness. In order to find out how effectively, how quickly, and most significantly, how effective the new 24-hour vehicle sleep monitoring system was, researchers tested it in both a calm lab and on packed roadways. A system is set up to send WhatsApp messages whenever it detects an eye blink [14]. Testing it on people with different face shapes, blinking movements, and lighting situations (from soft morning light to intense fluorescent glare) allowed us to make sure it would work in a range of real-world settings. Each person went through three separate phases: fully alert driving, a brief test of drowsiness that felt like a long blink, and a protracted process of eye closure that felt like extreme fatigue. A standard camera maintained a steady feed of live video during every session. Every eye movement of the driver was monitored. In every new scenario, the eye detection method developed by Haar and Cascades was accurate. Regardless of lighting conditions or partial facial masking, the presence or absence of open and closed eyes could be seen. Both spectacles and rapid head movement had no effect on the system's performance. The trials recorded blink rates every second, automatically classified them by minute using the panda’s package, and saved them to a CSV file. The result was a screen that seemed to be continuously pulsed. The data was meticulously recorded at all times, creating a large dataset that may be used for future behavioural and statistical research. So, researchers found that certain eye motions, such slowly dropping an eyelid, are associated with fatigue. The results showed that early signs of fatigue, including heavy eyelids and insufficient blinking, were significantly correlated with changes in blink rate. Although the drivers were fully conscious and aware, they would often close their eyes, as if pressing a shutter button on a camera. As their vitality dwindled, the blink rate decreased. The regular pattern in these pictures proved that the detection method worked, and that heavy eyelids after midnight or other prolonged periods of closed eyes are a sure sign that you're exhausted. Even during long test runs or small connection interruptions, the system's automated data recording capabilities reliably recorded entries, guaranteeing the safety of all data. According to the results, the AI system might instantly notify the driver if it detects early signs of exhaustion, such sluggish blinking. This aids people in being alert and avoiding accidents. The technology utilizes computer vision, real-time monitoring, and Internet of Things connection to turn passive observation into active accident avoidance. It may, for example, anticipate a spill and prevent a fall. This adaptable, hands-on architecture is the basis for the next generation of smart driver assistance technologies. It enhances travel safety and efficiency, making each turn.

7. Results

New AI optical alertness metric shows promise as a safe and secure driver safety measure after extensive investigation. It's like a small alarm goes off and your eyes start to roll back. The technology can see whether the driver is becoming sleepy and take action before their eyelids droop to a serious problem by analyzing photos in real-time, monitoring their actions, and sending them quick messages. No physiological data, such an electroencephalogram or heart rate, is required by this method. But it uses computer vision to its fullest potential. It tracks and evaluates eye states using OpenCV's HaarCascade classifier, similar to how a blink in the dark is seen. This visual technique is easy to use and works effectively on a wide scale, eliminating the need for costly, cumbersome equipment. It is also ready for usage in the real world. According to studies, if a person's eyelids remain closed for an extended period of time, it indicates that they are about to fall asleep. The system uses sequential logging and threshold-controlled blink tracking to make a design that is both strong and light. It works well even on computers with low power, like a laptop that is tapping softly on a desk or a small Raspberry Pi. This means that it can be employed by one car or for an entire fleet of cars. The best part about the system is that it has Twilio's WhatsApp alert module, which fills the gap between seeing a problem and fixing it [13]. It's like getting a warning buzz on your phone before anything goes wrong. Most of the previous studies only talked about tiredness, but this model starts working right away, sending quick alerts to many registered users as soon as signs appear. This method tells people about possible risks in just a few seconds, which lowers the chance of an accident before anyone even feels the sudden rush of danger. On average, notifications received in under two seconds during testing, suggesting that the gadget should function well with a regular home Wi-Fi connection. The ability to respond quickly is important in situations when a single signal might determine whether you swerve safely or collide with metal. You have more leeway and may change the alert channels with ease because to the modular design of the system. Not only can it run WhatsApp, but it can also do other tasks. To keep drivers alert, it may also deliver auditory alerts, dashboard flash warnings, or pop-up phone notifications, which might be a simple chime or flashing symbol. Multiple drivers may reap the advantages of this adaptability. Transportation units, large delivery fleets, and congested transportation networks might benefit from this as it is impossible to constantly monitor every driver. A few performance concerns were, however, uncovered during testing. Inadequate illumination or drivers using massive reflective sunglasses that block the eyes with a dazzling silver glare are two major contributors to Haar Cascade classifier errors. In very unusual cases, measurements may be slightly wrong for a second because of a powerful shock or head movement; nevertheless, these inaccuracies seldom affect the overall accuracy of the system. These limitations have sparked fascinating new lines of inquiry, such as improving the accuracy of eye detection via the use of deep learning[7] methods like convolution neural networks or making infrared imaging more capable of identifying eyeballs in low light. To further reduce the likelihood of false warnings during night driving long distances, the system may additionally learn the driver's blink threshold patterns. The results demonstrate that the design hits a sweet spot in terms of responsiveness, precision, and speed. To keep costs down and facilitate replication of research in intelligent transportation systems, such as rerunning traffic flow models using the same code and data, open-source technologies are a great choice. In addition to accomplishing its main goal of reducing accidents caused by distracted driving, this research lays the groundwork for an extensible system that can accommodate developments in AI-driven driver monitoring in the future. A dashboard that, for instance, learns how each driver drives over time.

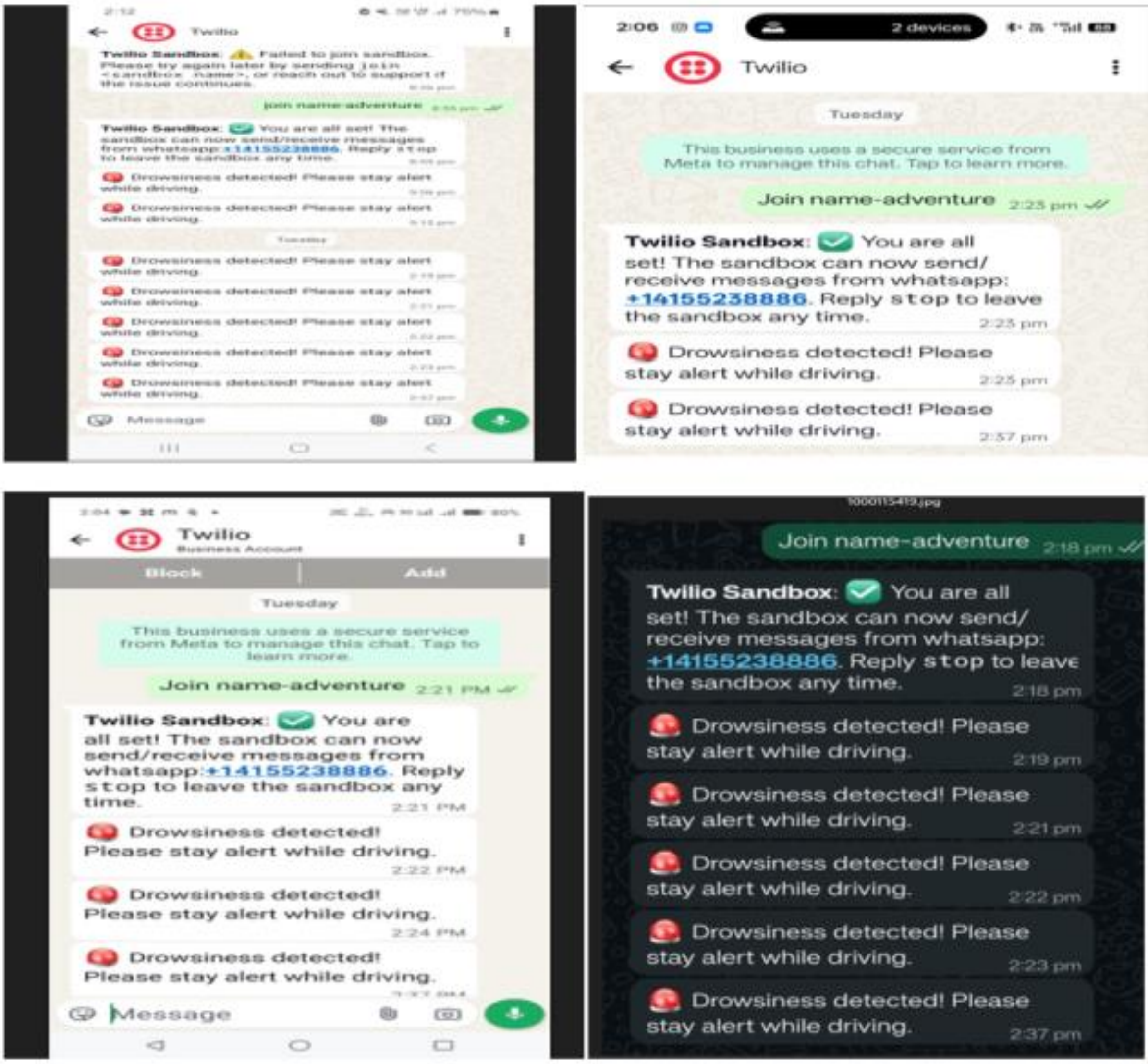

Figure 3. Results

8. Conclusion and Future Scope

This study introduces an AI-powered system that identifies signs of drowsiness, like drooping eyelids, and sends alerts to prevent accidents caused by fatigue. The system uses computer vision and instant messaging to quickly and cheaply check how alert a driver is. It can tell when their hands are tightening on the wheel and their focus is changing. The Haar Cascade classifier in OpenCV detects when someone's eyes are closed for too long and sends a WhatsApp message via Twilio. This is a timely warning that might prevent an accident. You can simply put it up with a standard webcam and some free software. It has several potential uses, such as a delivery van and a family car. The system logs every blink and appends a timestamp. In order to keep transportation operations safe, this gives you clear information that lets you know when someone is tired. To improve performance in low-light conditions, such a foggy night-time road, infrared or thermal imaging may be included in future upgrades. Improved accuracy in finding items might also be achieved with the use of deep learning models like CNNs or Vision Transformers. Edge devices like a Raspberry Pi or an NVIDIA Jetson, when combined with visual data, a driver's heart rate, or grip pressure, may provide a smart and all-encompassing assistance system. This initiative, if accomplished, will represent a significant step forward in the pursuit of more intelligent and secure forms of transportation. Take autonomous vehicles as an example; they could anticipate a slick spot ahead of time and switch lanes accordingly.

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