A Comprehensive IoT Approach to Enhance Truck Driver Safety

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Abstract**—** This research project presents an Internet of Things (IoT)-based solution intended to improve productivity and safety in Indian trucking operations. Using a Raspberry Pi 3/4 and sensor modules, the system closely observes several factors, such as driver behavior, vehicle circumstances (such as drowsiness driving duration, use of cargo space, and alcohol consumption), and driving quality evaluation. An extensive driver progress record is kept by the system in a centralized database. Furthermore, the dashboard functions as a real-time command center, providing insights into driver behavior and vehicle status, and is accessed through the 'Saathi' application. This software is noteworthy for giving drivers employment options, encouraging safe truck usage, and guaranteeing smooth truck administration by keeping an eye on important information including insurance coverage, truck information, and service needs. The project's main significance is that it could reduce accidents on Indian roads and provide truck drivers more clout in a competitive labor market. The project's goals, implementation details, outcomes, and consequences for the Indian transportation industry are outlined in the document, which also promises a significant improvement in accountability, efficiency, and safety.
Keywords—IoT, Operations, Raspberry Pi ¾, Drowsiness, Intoxication, Accidents.

I. INTRODUCTION

India's transport sector is vital to the country's economy since it links regions, promotes trade, and spurs development. The logistics of this huge and diverse nation are based on the movement of commodities by trucks and other commercial vehicles. The most pressing issue for this vital sector is road safety, but there are several others as well.

A shocking number of accidents occur on Indian roadways every year, causing injuries, fatalities, and high financial consequences. Driver weariness and drowsiness, which are frequently brought on by long periods of driving without enough rest, are one of the main causes contributing to these incidents. These collisions not only endanger other road users' safety but also put drivers' safety in jeopardy.

Our project, which is based on the Internet of Things (IoT), provides a novel and revolutionary solution—a driver aid system—in response to the pressing need to solve this issue. Our system is intended to improve road safety and maximize the effectiveness of trucking operations in India. It makes use of the computing capabilities of Raspberry Pi 3/4 and a variety of sensors, including cameras and GPS modules.

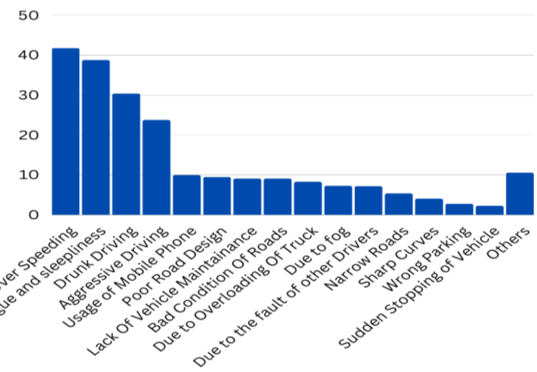
The Internet of Things-based driver assistance system offers a thorough strategy to reduce driver tiredness, track driving hours, and keep track of driver performance. Additionally, it offers an advanced web- and app-based dashboard that gives truck owners and drivers access to real-time information about their business. This dashboard not only makes sure the appropriate person is driving, but it also creates new employment opportunities, optimizes fleet management, and boosts overall operational effectiveness.[7]

In-depth discussion of our project's goals, approach, findings, and ramifications for the Indian transportation sector is provided in this study paper. Our initiative has the potential to drastically minimize accidents, offer truck drivers evidence of work in digital form, and bring about a significant shift in how goods are moved across the nation by offering a comprehensive solution to solve safety concerns and expedite operations.

We will give a thorough description of our project in the sections that follow, including its theoretical foundations, practical application, and potential wide-ranging effects on India's transport industry.

Problem Statement:

- Our main problem is accidents due to drowsiness, over speeding and driving hours.
- The shortage of drivers in the market led to overburdening of truck drivers with long working hours by the fleet owners, which caused fatigue and reduced the resting time.
- According to a survey on the status of truck drivers in India, over-speeding was stated as the major cause of road crashes by truck drivers as of February 2020.
- Fatigue and sleepiness were stated as the second major reason for road accidents among 38 percent of truck drivers in the South Asian country.[8][10]



Stats of Accidents according to 2020

II. LITERATURE REVIEW

The driver safety assistance research landscape includes a wide range of approaches and technologies intended to increase traffic safety. In this section, we examine various significant studies that have addressed the crucial problem of identifying sleepy drivers, over speeding and driving hours illuminating the multifaceted strategies used to meet this difficulty.

When your main attention is constantly on the road when driving, feeling sleepy is a common problem. Due to their irregular working hours, truck and bus drivers often have sleep deprivation, which contributes to several serious incidents that occur on the roadways. Less than 8 hours of sleep, a lack of a suitable sleeping environment, and a lack of a work schedule are some of the frequently reported variables causing this issue.

A driver's tiredness can be detected by a variety of facial changes, including yawning, head nodding, and eye blinking. The blinking of the eyes is the main factor taken into account here. A tired person blinks about 21 times per minute compared to a regular person's 15 blinks per minute. After processing the image and creating a matrix of it, the eye-detection code in MATLAB is used to determine how many blinks occur over a given period of time.[1]

All of this work is performed by a laptop, and according to the software's predetermined aim, if there are more blinks than a certain amount, an alarm will sound to remind the driver to keep focused or take a break.

Drivers who don't get enough sleep and rest are more likely to become sleepy while driving. Some prominent, noticeable signs of drowsiness include: eye blinking, yawning, and head rocking from side to side. Here, eye blinking was thought to be the most important component of all, and the project is built around it. Driving when drowsy increases the risk of accidents, so it should be avoided.

Driving when tired has been a fairly widespread problem that contributes to a lot of accidents on the road. The majority of collisions occur at night or in the late afternoon on fast routes, when there is little or no traffic, and the majority of the drivers are men (18 to 25 years old). This is the best scenario for feeling sleepy.

The three methods of measuring drowsiness—vehicle-based assessments, behavioural measures, and physiological measures—are put to use and contrasted.

In this study, the simulator of an automobile is used with a sleepy driver to maintain the driver's safety. Lack of sleep, the time of day, and longer driving hours can all contribute to tiredness. While conducting trials in the simulator, all of these elements were taken into account. The KSS drowsiness scale (1–9) was used to gauge the degree of drowsiness, with 1 denoting the best state for driving and 9 denoting the worst.[2]

The steering wheel movement and lane placement standard deviation were used in the vehicle-based method.

The behavioral measurement took into account yawning, head tilting, and eye blinking.

Physiological measurements have made use of a variety of bodily signals, including ECG and EMG.

The Physiological technique was the most prominent and trustworthy when all the methods were compared since it accurately predicted sleepiness. Due to camera positioning and poor nighttime lighting, the other method, the behavioral measure, sometimes uses a computer vision approach that is not particularly effective. In the long term, physiological measures can also be found to be intrusive, thus care must be made to ensure the driver is comfortable while driving.

The fact that these conclusions are based on a simulated setting rather than on actual conditions must also be taken into account.

A significant number of accidents are brought on by drowsiness each year, and the problem does not resolve itself. This research study develops an ADAS system based on image processing that uses the driver's eye blinking as a common indicator of their level of tiredness.[5] On the road, actual drivers served as the subjects of these examinations. These tests also take into account a number of additional strategies.

In this study, an algorithm to determine an eye's condition is used. The Digital Signal Processor (DSP) acts as its basis. Face detection is followed by Eyes localization, Eyes tracking, Eyes state, and Driver state.[5]

When a driver's eyes are closed for more than five consecutive frames, it indicates that they are tired and an alarm is set off.

S.No.	Title	Author Name	Technology Used / Result
1.	Design of a Vehicle Driver Drowsiness Detection System through Image Processing using MATLAB	Namagiri Suresh, Gayam Akil, B. Vijaya Krishna, M.G. Adithya	MATLAB and HAAR Algorithm
2.	Detecting Driver Drowsiness Based on Sensors: A Review	Arun Sahayadhas, Kenneth Sundaraj, Murugappan Murugappan	KSS drowsiness scale (1-9)
3.	Driver Drowsiness Detection System	Jagbeer Singh, Ritika Kanojia, Rishika Singh, Rishita Bansal, Sakshi Bansal	ADAS System
4.	Driver Drowsiness Detection using Eye-Closeness Detection	Oraan Khunpis uth, Taweechai Chotchinasri, Varakorn Koschakosai, Narit Hnoohom	HAAR Cascade Classifier 98.85% accurate
5.	Driver Drowsiness Detection	K. Satish; A. Lalitesh; K. Bhargavi; M.Sishir Prem; T Anjali.	Use HOG and OpenCV 96% accurate

In this experiment, drowsiness is looked out and reported when it is.

It is accomplished using an infrared camera, which is also capable of seeing in low light. The choice of the eye states is made using the Hough Transform for Circles.

Results show excellent accuracy and a very low false-positive rate, indicating that the design is sound and workable.

In the developing world, car accidents are a big problem. Accidents resulting from driver intoxication are among the most often noted driver errors. The authors of this research have made efforts to enhance the eye-closeness detecting technology that Volkswagen has installed in its vehicles. The most common issues faced in the vehicle were: Lighting conditions, driver wearing eyeglasses, and dark skin tone.

The image was taken using a Raspberry Pi 3 and a Raspberry camera module. To ensure that the driver was maintaining proper eye contact, the following techniques were used: Face detection using the following steps: Geometric rotation, Haar Cascade Classifier, region of interest, eye detection, and eye closeness detection. Here, geometrical rotation is exploited to overcome the Haar Cascade classifier's constraint and obtain the driver's head tilt.

The cheapest option selected was the Raspberry Pi 3, which can be upgraded for faster calculations. The algorithm was originally applied to cell phone-taken images before being transferred to a Raspberry Pi 3. Based on the sample data, it demonstrated a 99.85% accuracy rate, which was respectable.[3]
Although further advancements are required for applicability in the real world.
Drowsiness has been a major issue leading to tragic accidents all over the world. There have been numerous suggested solutions to this problem, some of which include wearable technology and external hardware that ultimately affects the comfort of the driver while driving. The author of this method has developed an experimental setup that uses both eye blinking and hand pressure on the steering wheel to identify tiredness.
OpenCV and HOG are the software and Arduino UNO is the used hardware.[4]
Data was gathered and examined while driving normally. According to the author's established threshold value, the alarm won't go off if the user doesn't keep their eyes on the road and their eye blinking rate is above a certain rate and their pressure on the steering wheel is below a certain threshold value.
It was discovered that this methodology provides an accurate result regarding the driver being sleepy
96% of the time when compared to other methods and procedures where both approaches (eye blinking and hand pressure) weren't used together. Among all the methods, this is the highest.
The hardware, which is a touch intrusive, is the only restriction.
These studies collectively highlight the pressing issue of driver drowsiness and the innovative approaches employed to address it. From image processing to physiological and behavioural measures, each approach offers unique insights into mitigating the risks of drowsy driving, providing valuable guidance for our project's development of an IoT-based driver assistance system.

III. TECHNOLOGY USED

In the proposed methodology we use different technology:
Internet Of Things:
The IoT technology, which consists of a network of connected devices and sensors, is at the core of our solution. IoT-capable elements, such as cameras and different sensors, were carefully placed around the vehicle. These sensors captured crucial information about the driver's behaviour since they continuously collected and communicated data in real-time.[7]
Flutter:
For developing a user-friendly mobile application, we used the Flutter framework. Because of Flutter's cross-platform interoperability, we were able to develop an app that worked on both iOS and Android devices. The main communication channel between the driver and our safety system was this app. It offered information about the driver's alertness in real-time and a system for sending alarms and notifications when drowsiness was noticed.
Firebase:
Our database administration relied on Firebase, a strong platform for creating mobile and online applications. It aided in the organisation, storage, and retrieval of data produced by IoT sensors and user interactions with the app. The real-time database capabilities of Firebase made sure that the data shown on the app's dashboard was accurate and up to date. Furthermore, the system's security and responsiveness were improved by its authentication and cloud messaging features.

Our research effort produced a comprehensive and successful Driver safety assistance system solution by integrating IoT, Flutter, and Firebase. These technologies worked together to create a workable, user-cantered solution that improves traffic safety and reduces the dangers of sleepy driving.

IV. COMPONENT DESCRIPTION

In the proposed methodology we use following components:
Eye blink sensor:
The key component of our tiredness detection technology was the eye blink sensor. This sensor is intended to continuously track the driver's eye blinking patterns. It functions as a critical indicator of the driver's state of attention by continuously monitoring the number and length of eye blinks. The system detects probable tiredness when blinking becomes more frequent or when the eyes are closed for an extended period of time. To improve road safety, this data is then processed and analysed to send timely cautions or alarms to the driver.
ESP32:
The brain of our system was the ESP32 microcontroller. This strong and adaptable microcontroller has a Wi-Fi connection capability, allowing for seamless communication with the mobile app. It coordinated the processing and delivery of the information to the app after gathering data from the eye blink sensor and other different sensor Responses from the system were quick and efficient because to the ESP32's computing power and connection characteristics.[9][10]
MQ3:
The MQ-3 gas sensor, which was created specifically to identify the presence of alcohol and other hazardous gases in the vehicle's cabin air, is an essential part of our research effort. By monitoring these compounds, which might affect a driver's focus and present threats to road safety, this sensor plays a significant role in improving driver safety.[6]

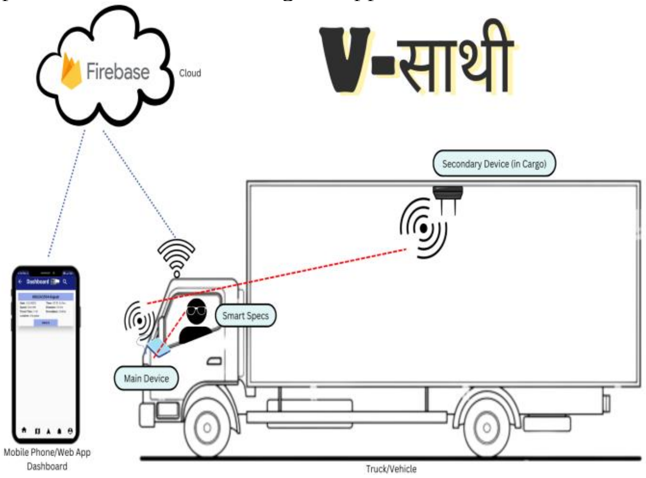
GPS:
We used a GPS (Global Positioning System) sensor in our research project to enable accurate and real-time location tracking. The GPS sensor is a crucial part of our system that ensures precise positioning and improves overall performance.[9]

DHT11:
A DHT11 sensor was incorporated into our research project to track the ambient conditions in a vehicle's cargo area. The DHT11 sensor is made to measure temperature and

humidity and using it to monitor cargo space has several advantages.

Wireless Communication Transceiver Module NRF24L01 (NRF2401L):

We used NRF24L01, also known as NRF2401L, as a crucial part of wireless communication in our research project. A flexible and frequently used transceiver module, the NRF24L01 is renowned for providing dependable performance in a wide range of applications.



V. PROPOSED SYSTEM

The suggested system makes extensive use of sensors, wireless communication modules, and cloud-based services to improve driver safety. This technology is meant to offer real time insights into driver lack of attention and the state of the load being delivered. The following are the main elements of the suggested system:

Driver safety monitoring

The integration of an eye-blink sensor into specifically design non-interrupting light weight eye glass for inconspicuous driver drowsiness monitoring.

The sensor detects and evaluates the driver's eye-blink patterns in real-time.

The central processing unit (Main Unit) receives information on driver drowsiness.

Primary Unit

The Main Unit, which is the central component of the system, is mounted on the dashboard of the car.

According to predetermined algorithms, it collects and interprets data from the eye-blink sensor to determine the driver's level of awareness.

For real-time vehicle tracking and speed monitoring, the Main Unit has a GPS.

Connecting to the cloud-based platform Firebase ensures secure data management and storage.

Monitoring of cargo (Optional):

installation of a "Secondary Unit" to monitor temperature, humidity, and other variables in the cargo area.

Through NRF2401L wireless communication, data from the Secondary Unit is sent to the Main Unit.

Added security measure:

The Main Unit will incorporate a MQ-3 sensor to look for the presence of alcohol and other dangerous gases there.

User interface and data management:

Data is safely uploaded to Firebase, including sensor readings, vehicle position, cargo conditions, and driver sleepiness.

Flutter is used to create a user-friendly dashboard that offers real-time data monitoring and analysis for web interfaces and mobile applications.

The system is set up to send warnings and alarms in response to particular circumstances, such as drowsy.

driving, problematic cargo, or the presence of alcohol, with notifications going to selected receivers for prompt action.

VI. PROPOSED METHODOLOGY

The following is the methodology for the proposed system:

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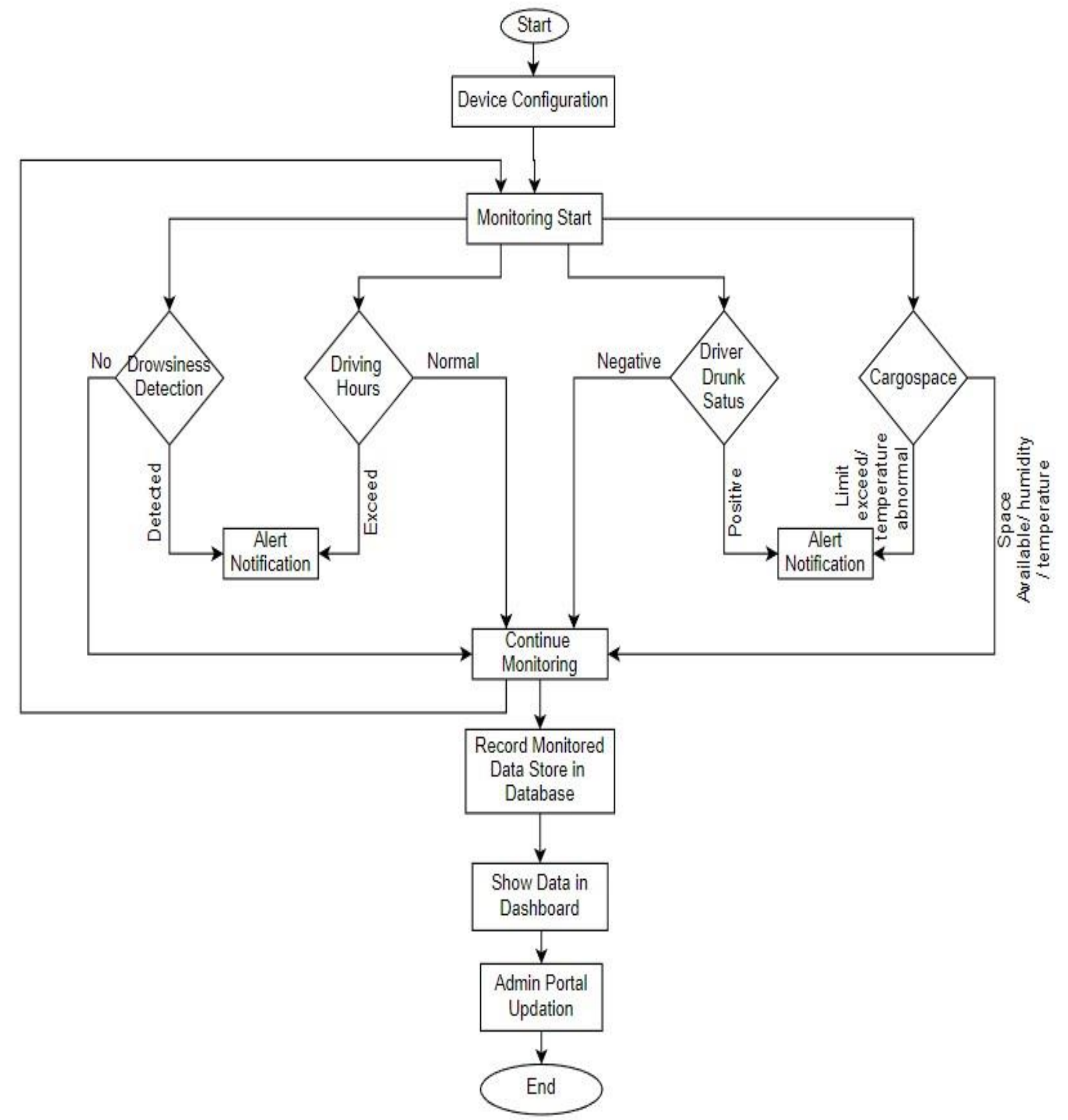
- The system starts with an eye-blink sensor integrated into specially made non-interrupting light weight eye glass.
- The eye-blink sensor computes the blink rate while continually observing the driver's eye blinks.
- An average individual blinks 15 times per minute, whereas a sleepy person blinks 21 times per minute.
- For analysis, the primary unit receives the data from the eye-blink sensor.
- The MQ-3 sensor simultaneously finds any gas in the surrounding air, including alcohol. The sensor keeps an eye out for dangerous gases in the air.
- The primary unit receives data from the MQ-3 sensor for in-the-moment analysis.
- The system also incorporates a GPS tracker to offer real-time location information.
- Real-time tracking and monitoring are made possible by the GPS module, which constantly transmits the primary unit the location of the vehicle.

- A DHT11 sensor that is mounted in the cargo area keeps an eye on variables like humidity and temperature. To guarantee that cargo conditions are kept within allowable bounds, the driver can configure the DHT11 sensor with specific parameters.
- Data on cargo conditions is continuously gathered by the DHT11 sensor and sent to the main unit for analysis.
- For safe and scalable data management, all information—including eye-blink rate, gas sensor readings, GPS location, and cargo conditions—is kept in a Firebase database.
- A web or mobile application built with Flutter is created to communicate with the system.
- Data is retrieved from the Firebase database and shown in a user-friendly manner by the Flutter application.
- The app is designed to evaluate incoming data and send out warnings in response to preset criteria. Alerts might tell the driver to take a break, keep focused, or deal with cargo issues.

By giving a complete solution for sleepiness detection, environmental monitoring, and position tracking, the integrated system improves road safety and cargo security by giving real-time insights to the driver and pertinent stakeholders.



VII. RESULT

The created multi-feature system shows high precision in addition to providing a thorough approach to environmental sensing, cargo monitoring, and driver safety. A key element of sleepiness detection is the eye-blink sensor, which accurately picks up on even minute changes in the driver's state. This high degree of accuracy is essential to preventing sleep-related mishaps. The technology is a ground-breaking approach that has the potential to greatly increase safety in the transportation sector because of its accuracy, which is a notable advance above earlier research. Furthermore, the combination of live GPS tracking, cargo space monitoring, and gas sensing guarantees that cargo integrity and road safety are maintained at all times. The uniqueness and unparalleled accuracy of this method mark a significant advancement in the sector.

VIII. CONCLUSION

In conclusion, our study has produced a novel, multipurpose technology that has the potential to revolutionize driver safety in the commercial transportation industry. This technology adopts a complete strategy by tackling environmental concerns, cargo security, and driver fatigue.

Our approach offers a more comprehensive answer than other research articles that frequently concentrate on certain areas of driver sleepiness detection. It provides a greater degree of safety and security while attending to a wider range of transportation-related needs.

The protection of transported products and road safety have significantly improved as a result of the combination of numerous technologies and components. In addition to detecting driver fatigue, our system protects cargo and keeps an eye on the weather, all of which will make the industry safer and more productive in the future.

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