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Road Accident Prevention using AIRAVAT: Artificial Intelligence-based Real-time Advanced Vehicle Administration Technology

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Abstract: In the modern era of advanced technology, many urban areas are equipped with surveillance cameras linked to traffic management systems. Several road accidents result in severe damage to vehicles, and property as well as human injury sometimes leading to death. Road accidents are the eighth major cause of death among the young generation and have affected millions of people every year. Thus, the topic has gathered widespread attention for research wide attention to the topic for research. The study aims to reduce the accidents caused by driving conditions such as health, speed, control issues, or drowsiness and vehicle conditions. Additionally, it pursues to enhance the overall efficiency and safety of transportation systems. Utilizing advanced computer vision techniques can enhance the performance of the systems for automatic detection of accidents. The study proposed a framework - Artificial Intelligence-based Real-time Advanced Vehicle Administration Technology (AIRAVAT). It is based on the registration of drivers across the road network and vehicle authentication for safe and secure journeys. The administration system ensures the vehicle's condition and also monitors the driver's condition using advanced AI techniques. It sends alerts to drivers in case signs of drowsiness are detected. The centralized control system facilitates mobile apps with easier access from any location. The proposed system provides valuable insights for reducing road accidents and consequently saves human lives from injuries and fatalities. Ultimately, the proposed project establishes a roadmap for reducing accidents through real-time traffic control.

Keywords: *Artificial Intelligence, Real-Time Vehicle Administration, Traffic Control, Accident Detection*

1. Introduction

Urban traffic management faces a significant challenge at intersections, where conflicts and accidents often occur. Drivers in a dilemma zone may speed during the green-to-yellow changeover, resulting in rear-end and angle crashes. Despite efforts to discourage unsafe behaviour, running red lights is however popular. Other potentially dangerous activities, such as unexpected lane changes and unanticipated movements by pedestrians or cyclists, can be caused by traffic control systems or intersection layouts. It is critical to detect potential conflicts as soon as possible in order to establish effective tactics for mitigating their effects. Most traffic management systems now rely on manual monitoring of surveillance camera footage from intersections. Automatic traffic accident detection employing computer vision technology has a massive capacity for improving these systems [1]. Previous research has used computer vision in traffic surveillance for a variety of functions, including the possibility of automating accident detection [2]. This not only eliminates manual labour but also allows paramedics and emergency services to respond quickly. Automatically detecting accidents also gives vital data for altering signal operations and intersection layouts to avoid serious crashes.

Road traffic accidents cause the death of approximately 1.19 million lives per year. It has a disproportionate impact on young people aged 5 to 29 years, making it the main cause of death and injury in this age group [3]. As a result, there is an intensive effort to apply improved procedures to reduce these incidents. Corresponding to the Brasilia Declaration, India desires to reduce road accidents and fatalities by half by 2022. Legislative initiatives are initiated addressing road safety, third-party insurance, and accident-related issues, such as the Motor Vehicles (Amendment) Bill, 2016. With the encouraging results of emerging AI approaches in surveillance applications, it is feasible to use them for real-time monitoring and management of road networks. AI can dramatically improve the accuracy of traffic surveillance, lowering the probability of an accident [4]. The fundamental objective of this research is to provide a robust framework called "AIRAVAT" (Artificial Intelligence-based Real-time Advanced Vehicle Administration Technology), which integrates AI for real-time vehicle monitoring and improves traffic control systems. This framework monitors vehicle and driver conditions and issues real-time notifications to protect human lives from potential hazards.

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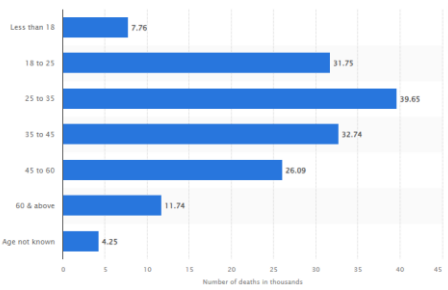

Fig. 1. Road Accident Deaths in India (Agewise) [5]

In road accidents, driver drowsiness is a critical aspect considering signs of fatigue, sleepiness, or decreased alertness during driving. It can be observed in cases of insufficient sleep, extended driving periods, and monotonous environments. An effective approach to detect driver drowsiness involves eye-blink analysis, monitoring the frequency and pattern changes of eye blinks during driving [6]. These eye-blink variations serve as indicators of a driver's alertness level, with decreased blink frequency or prolonged eye closure indicating drowsiness. It facilitates real-time monitoring to assess a driver's condition and alertness. Implementing this approach holds promise in significantly reducing road accidents and enhancing overall road safety [7].

1.1. Causes of road accidents

Road accidents are caused by several causes, such as cell phone use, fatigue or sleepiness, drug and alcohol use, and inattention [8]. It also includes risky driving behaviours such as rash driving or excessive speed. Driver-related factors such road accidents are caused by several causes, such as cell phone use, fatigue or sleepiness, drug and alcohol use, and inattention [8]. It also includes risky driving behaviours such as rash driving or excessive speed. Driver-related factors such as skill level, inexperience, risk-taking behaviour, and traffic offences all have a substantial role in accidents. Major triggers to road accidents include excessive speed, loss of control, failure to identify another vehicle, and failure to obey signs and signals. Accidents can also occur as a result of failing to observe objects, inappropriate turns, or lane changes. In senior drivers, age-related losses in visual, cognitive, and movement functions, medical disorders such as heart disease or stroke, and driver impairment all play important roles [9]. Risks are also posed by the road environment and vehicle problems. Understanding these causes emphasises the crucial importance of driver attentiveness, respect for regulations and laws, and a concerted effort to decrease these risk factors through increased vigilance and safe driving behaviours.

1.2. Scope of the Study

The scope of the study aligns with the demanding issue of road accidents in India. According to the National Crime Records Bureau, more than 400 deaths occur daily due to road accidents in India with the highest number of road accident deaths worldwide [10]. The key reasons contributing to the highest rate of road accidents in India include noncompliance with safety standards, lack of traffic management, and insufficient execution of traffic rules and regulations, in addition to prevalent instances of drunk driving, speeding, and reckless driving. Moreover, the role of poorly maintained vehicles increases the rate while a lack of public awareness about road safety further worsens the issue. However, in legislative measures, the Motor Vehicle Act, 2019, has introduced strict fines and penalties for traffic violations. It prevents behaviours such as overspeeding, drunk driving, and driving without a valid license [11]. The act also emphasizes improved road safety measures, including the mandatory use of helmets and seat belts, alongside stricter regulations for commercial vehicles. Furthermore, initiative measures like the installation of crucial safety features like airbags, anti-lock braking systems (ABS), and electronic stability control (ESC) in new cars, are essential to enhance vehicle safety [12]. Addressing the issues is prevented by heavy fines, license suspension, and even imprisonment for offenders. Also, the speed limits on different types of roads ensure that drivers maintain safe speeds for accident prevention. All these preventive measures need to be effectively implemented and monitored to reduce road accidents.

Therefore, the proposed architecture of AIRAVAT aims to proactively prevent accidents through real-time monitoring of drivers and vehicles along with advanced administration techniques using novel artificial intelligence (AI) technology. By leveraging AI technology and software systems, this study offers comprehensive real-time monitoring of drivers' behaviours, vehicle conditions, and road safety factors. The purpose of the study is to create a robust system that integrates cutting-edge technology to enhance road safety, reduce accidents, and save lives by ensuring efficient and effective administration and management of road networks.

2. Related Work

Several studies focused on driver drowsiness detection methods using several types of techniques like computer-vision techniques, machine learning, and physiological signals. A study [13] proposed a drowsiness detection approach utilizing eye-blink and yawning features by analyzing video footage of drivers. The study measures drowsiness levels based on the frequency and duration of eye blinks and yawns. Employing computer-vision techniques, this study extracted pertinent features like eye-blink and yawning from driver video sequences offering more reliability in drowsiness detection. These findings suggest the potential real-world application of this method in enhancing road safety and mitigating drowsy driving

accidents.

Eye-movement detection involves identifying and measuring eye movements, offering insights into attention, perception, and cognitive processes. This detection technique is widely used for exploring visual and auditory processing, and diverse behavioural aspects of human performance [14]. Various methods are employed for eye-movement detection like EOG (Electrooculography) [15] which measures the electrical potential difference around the eyes, primarily capturing horizontal and vertical eye movements. On the other hand, Infrared (IR) eye trackers [16] use infrared light to track eye movements, often focusing on the reflection of infrared light off the cornea or analyzing pupil dilation.

However, widely used video-based eye trackers use video cameras to record eye movements, interpreting changes in the eye's position or pupil size [17]. Dual-purpose tracking combines different technologies or modalities to measure eye movements, enhancing accuracy and versatility in monitoring. In computer vision, the key focus lies in eye detection and tracking within images. These tasks pose challenges due to factors like variations in eye sizes and degrees of openness. Employing video cameras, these methods capture and analyze eye movements. Such systems can track eye movements either in real-time setups or controlled lab environments. The fundamental principle involves utilizing image processing to locate and monitor pupil positions in video streams, subsequently inferring gaze direction.

Video-based eye-tracking systems commonly include remote and wearable systems based on cameras placed at a distance and cameras closer to the participant, respectively. Wearable setups offer a more comprehensive gaze behaviour overview. Recent studies have examined video-based eye tracking [18] where real-time eye tracking uses deep learning (CNNs and RNNs) with astonishing improvement in accuracy as well as speed. Another PCA model [19] reduces image pixel dimensionality based on an ANN for pupil position classification via calibration. Additionally, Lui et al. [20] presented eye detection and tracking methods involving Viola–Jones face detection and template matching for eye detection, utilizing methods such as Zernike moments and SVMs for eye or non-eye classification without copying from the original text.

However, the existing studies lack important factors like vehicle condition, driver health, etc. Furthermore, these systems lack robust administration systems to collect vital data and connect drivers to online road networks. These systems also lack real-world application. Thus, the proposed system addresses these issues and aims to bridge this gap by practical implementation, potentially improving road safety in driving scenarios.

3. Methodology

The proposed project "AIRAVAT" stands for Artificial Intelligence based Real-time Advanced Vehicle Administration Technology. It is based on the concept of removing obstacles for a safe and secure journey. The AIRAVAT is "Three-headed Elephant" signifying three aspects of "Driver, Vehicle and Data centre". Using these three elements, the proposed system aims to reduce Road accidents and to save human life because life is very precious. Thus, the website is provided where drivers can register before starting the journey.

Fig. 2. AIRAVAT Symbolized diagram

3.1. System Design

The system includes gate pass management and a data center along with real real-time monitoring system. The initial data collection determines whether all data is adequate to issue the gate pass. Moreover, the data centre collects real-time data for drowsiness detection. The figure shows the architecture of the proposed AIRAVAT System.

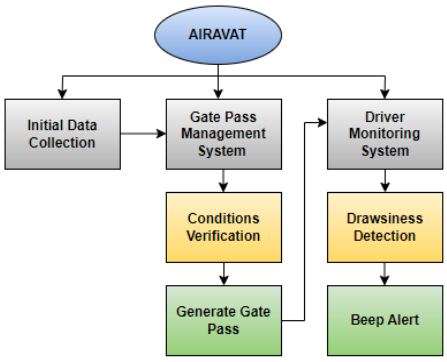

Fig. 3. Architecture of the proposed AIRAVAT System

- **Initial Data Collection:**

The initial data collection requires the driver's as well as the vehicle's information in addition to journey information and route mapping. The driver issuing the gate pass needs to answer certain questions to provide details like:

1. Driver's details
2. Driver's health condition
3. Vehicle's details
4. Vehicle's condition
5. Journey details

These details are important for allowing access to the road network. Before generating a Gate pass, the framework ensures adequate parameters align for a safe and secure journey by employing an authorized AI-based administrator. Additionally, National Identification Cards (NIC) can serve as authentication for both driver and vehicle.

- **Gate Pass Management:**

Once all required details are provided and conditions are fulfilled, the system registers the driver. It confirms registration via mobile number and a Gate pass is generated. Once the Gate pass is successfully generated, the system sends a message "You can start your journey" while after completion of the journey, it generates the message "Thank you! For safe and secure driving."

Gate pass management is a crucial measure to record the entrance and exit of drivers and vehicles within the Road Network. Technological advancements introduced web-based gate pass management systems accessible through computers as well as mobiles. Smartphones have attracted numerous users towards utilizing mobile internet access and web-based systems. Despite the advantages of smartphones in terms of portability, flexibility, and user experience, their small screen size and input methods present challenges when accessing web-based gate pass management systems. However, mobile applications have significantly improved user experience and simplified access for gate pass users with a more user-friendly interface. Leveraging the portability and accessibility of mobile phones, these applications ensure users can conveniently manage gate passes anytime and anywhere within the Road Network. Thus, it offers an easier way to handle gate pass procedures through the users' smartphones.

- **Driver Monitoring System:**

The project utilizes OpenCV and face immutils as inputs for continuously monitoring the driver in real-time, while the Advanced Vehicle Administrator serves as a data centre console for vehicle administration. The mobile application connects real-time camera surveillance to the data centre, continuously monitoring the drivers' live performance or status. As shown in the figure, the application initiates by focusing the camera on the driver's face. After face detection, the camera captures frames and processes eye detection.

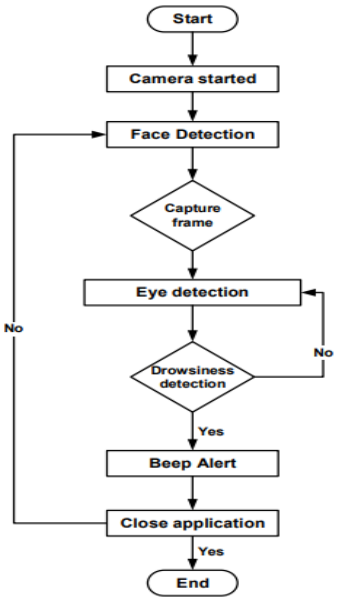

Fig. 4. Flowchart of Real-Time Driver Drowsiness Monitoring System

The data is continuously processed for drowsiness detection. When the system detects drowsiness based on eye movement irregularities, such as variations in eye blink rate and duration of eye closure, it triggers an alert for the driver, indicated by a beeping sound. In addition, if the camera detects any issues related to the driver's health condition or identifies a breach of standard conditions or regulations, the system activates an alert and sends a warning message to the driver. In cases of emergencies, the message may also be forwarded to the disaster management system. This continues as long as the application remains open. Upon completion of the journey, the application is closed.

4. Results

When a user enters the AIRAVAT real-time monitoring system, the system collects pertinent data for registering the driver and vehicle across the road network. If all conditions are fulfilled, it generates a gate pass following the steps outlined below.

1. Collect drivers details:

It includes name, age, mobile number, registration details, mobile number, email ID, blood group, etc.

Fig. 5. Driver's details

2. Investigate the driver's health condition:

It enquires about health conditions like Blood pressure, any health problems, alcohol consumption, etc.

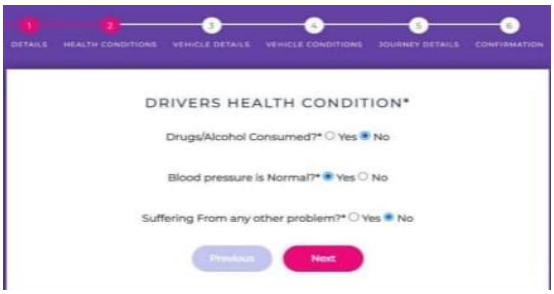

Fig. 6. Driver's Health Condition

3. Collects vehicle's details:

It includes vehicle information like vehicle number, registration number etc.

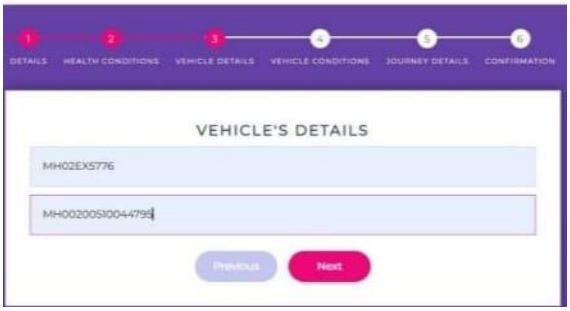

Fig. 7. Vehicle's Details

4. Collects Journey details:

It includes the source and destination of the journey, date, time etc.

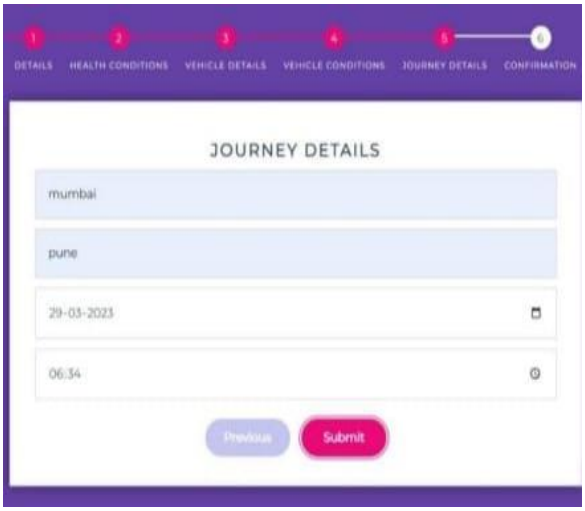

Fig. 8. Journey Details

5. Generate Gate Pass:

It shows details like the driver's name, vehicle number, source and destination of journey, etc.

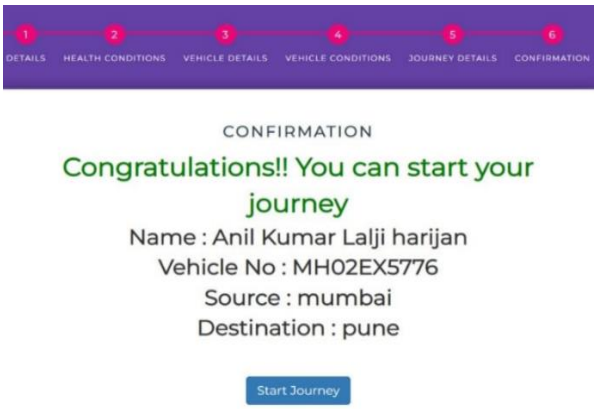

Fig. 9. Gate Pass Generated

After registration, the driver can start the journey and activate the real-time Advanced Vehicle Administrator. The camera detects whether the eyes are open or closed. If open eyes are detected, the system continues monitoring, as shown in the figure below.

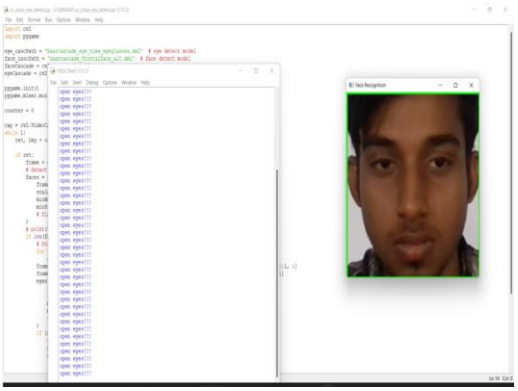

Fig. 10. Open eyes detection

In case closed eyes are detected, as shown in the figure, the system generates a beep alert for the driver.

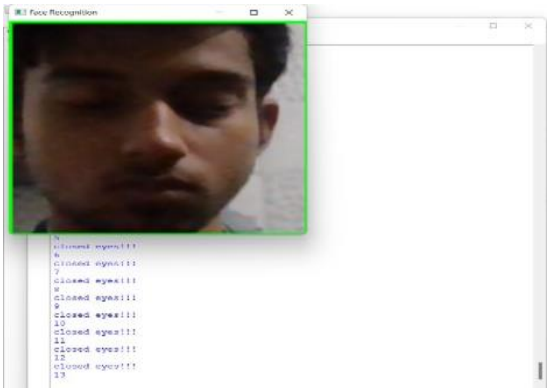

Fig. 11. Closed eyes detection

5. Discussion

The proposed system, AIRAVAT (AI-based Real-time Advanced Vehicle Administrator) efficiently minimises road accidents caused by driver fatigue or medical issues. This cutting-edge technology provides a comprehensive solution for improving traffic safety and efficiency in modern civilizations. It functions in a multi-stage manner

including information gathering, information processing and service delivery as discussed below.

It collects real-time driver, vehicle, and traffic-related data using AI-enabled networks, including participatory networks. It uses acquired data to identify potential transportation dangers, with an emphasis on improving safety measures. Then it offers customised services to regulate and reduce identified traffic hazards, with the goal of increasing overall traffic efficiency and safety.

Entities in the infrastructure-based system rely on a Central Controller to detect and respond to traffic hazards. Data processing enables the detection of events that have a direct impact on traffic efficiency. Targeted services are provided during the service delivery phase based on recognised dangers to optimise traffic conditions and safety measures. This systematic approach to data gathering, analysis, and response service supply highlights AIRAVAT's efficiency and efficacy in considerably lowering the occurrence of road accidents caused by driver-related concerns.

6. Conclusion

The study implements a highly efficient framework of "AIRAVAT" focusing on the development of a safety technology for preventing road accidents caused by drivers falling asleep while driving. The purpose of the study is to construct a system capable of detecting when a person's eyes are closed for a few seconds. To achieve this, the study integrated the AI technique with the computer vision technique for capturing the person's face every second and storing it as frames. The frames processed using a deep learning model classify whether the person's eyes are open or closed. The implementation of AIRAVAT signifies a significant step toward enhancing road safety by addressing the issue of drowsy driving through innovative technological solutions. By effectively detecting moments of closed eyes during driving, this system can potentially prevent accidents caused by driver drowsiness, ultimately contributing to safer roads and reducing vehicular accidents.

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Author contributions

Sachin Nemichand Gore: Conceptualization, Methodology, Software, Field study, Data curation, Writing-Original draft preparation, Software, Validation, Field study, Writing. **Dr. K. Lakshmi Sudha:** Visualization, Investigation, Reviewing and Editing.

Conflicts of interest

The authors declare no conflicts of interest.

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