WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Enhancing Road Safety: An Integrated IoT and AI Approach for Car Accident Prevention and Detection

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DOI: https://doi.org/10.55248/gengpi.5.0324.0654

ABSTRACT—

Car accidents are considered one of the most destructive phenomena. Though there are many different reasons behind car accidents, driver negligence and excessive speed are the most common causes. Additionally, it appears that lack of awareness makes it difficult to get at the scene of the collision in time. The World Health Organization (WHO) estimates that there are 50 million injuries and 1.4 million deaths worldwide each year. To address this, we propose an intelligent system that harnesses the power of IoT and AI. Our suggested intelligent system monitors and controls vehicle speed based on distance sensor data, utilizing AI and IoT to improve vehicle safety. In addition to warning the driver, this technology may change its speed on its own as necessary. To guarantee a timely reaction and responsibility in the case of an accident, the system quickly sends email alerts with vehicle information.

Keywords— Accident, IoT, AI, sensor, Road Safety, rescue, email.

1. Introduction

Roughly 1.35 million people lose their lives in traffic accidents every year. More than 20 to 50 million people experience non-fatal injuries as a result of these mishaps and many of these injuries result in disabilities. Globally, traffic accidents cost $518 billion USD, with each nation bearing costs ranging from 1% to 2% of GDP [1]. The difficulty lies in lowering the accident rate. Which makes it preferable to intervene before an accident happens. But sometimes we have no control over it. As a result, many injured people pass away since they were not told in advance. Given the situation, an automated intelligent system would be the best option. The existing solution provides assistance to passengers when an accident occurs. The injured must launch the system to request for help manually. But it would not have been possible if he/she were under critical or serious nonvital situation. There exists no system that controls vehicle speed to prevent accidents with automatic alert.

In our proposed research paper, "Enhancing Road Safety: An Integrated IoT and AI Approach for Car Accident Prevention and Detection," we introduce a ground-breaking IoT and AI-based smart system that functions seamlessly without requiring user intervention while driving or in emergency situations like accidents. This device automatically regulates vehicle speed and provides drivers with real-time vehicle notifications. It is a complete solution for preventing vehicular accidents since it includes both accident detection and reporting features. The general public stands to gain the most from this system because it increases road safety for all users. The following are the main contributions of our study:

(a) Creation of a revolutionary Smart IoT and AI-Based Solution: We introduce a revolutionary smart IoT and AI-based solution with the potential to significantly lower the frequency of traffic accidents.

(b) Community warns for Lower Fatality Rates: Our system warns the community in a timely and efficient manner, which helps to lower the number of fatal accidents.

(c) Automated Speed Control: By applying AI algorithms to reduce excessive speeding, we improve safety by establishing a speed control system that responds when critical situations are identified.

(d) AI-Driven Alert Systems to Increase Driver Awareness: We offer an AI-driven alert system designed to raise driver awareness and lower the probability of accidents brought on by carelessness or a lack of knowledge.

(e) Obstacle Distance Monitoring: The system uses AI-powered computer vision to actively monitor the distance between the vehicle and objects, adding an extra layer of safety to help avoid crashes.

2. RELATED WORKS

This section explores the benefits and drawbacks of comparable current systems while ignoring others. Numerous methods are available that merely identify accidents. There hasn't been a mechanism in place to effectively prevent and identify accidents at the same time. Vehicle accident notification and detection software A system that detects automobile accidents using a vibration sensor and alerts the police control center for assistance was proposed utilizing a GSM and GPS Modem [2]. There is no accident prevention system in this system. A rescue method involving notifying the location of an accident together with other information was presented in An IoT Approach to Vehicle Accident Detection, notifying, and Navigation [3]. There is no system in place to avoid accidents. Alcohol Detection and Accident Prevention of car [4]: This system makes use of a sensor that detects alcohol gases within the car and alerts the driver's family members of the location. This method is helpful for certain purposes only; it is not effective for general accident detection and prevention. This study suggests an Accident Detection and Reporting System employing GPS, GPRS, and GSM Technology [5] that is capable of detecting accidents based on monitored speed and sending a warning to police stations. Using GPS, a vehicle's speed will be tracked and compared. There are no alarm features in this system that might stop accidents. Internet of Things-Based Vehicle Safety notify and Tracking System: A Study and Implementation [6] This system's goal is to notify for an accident and vehicle theft. This technique can pinpoint the site of accidents. It lacks any accident prevention equipment.

3. PROPOSED METHODOLOGY

We give a high-level overview of our suggested system in this part, highlighting the use of artificial intelligence (AI) technology. The innovative technology described in our research study is intended to actively avoid vehicle crashes wherever feasible. In the case of an accident, it also swiftly alerts the proper authorities. Ultrasonic sensors enable the system's primary function, which is to monitor the space between cars. These sensors provide real-time data updates while continually measuring the distance between the host car and other vehicles on the road. Not only is this distance data gathered, but it is also intelligently analyzed utilizing AI algorithms. Based on specified parameters, the system analyses this data and sends signals to the driver, such as a warning to apply the brakes, an advice to slow down, or a safe following distance. The system uses a variety of signs, such as sounding the car alarm, to notify the driver. For instance, a yellow LED alert is shown to notify the driver when two cars are getting near to one another. However, if a dangerously close distance exists between two cars, the system triggers a red LED alert and emits a buzzer sound to warn of a potential accident. In order to give the driver real-time awareness throughout, the system continuously shows the distance between the host car and other vehicles on an interface.

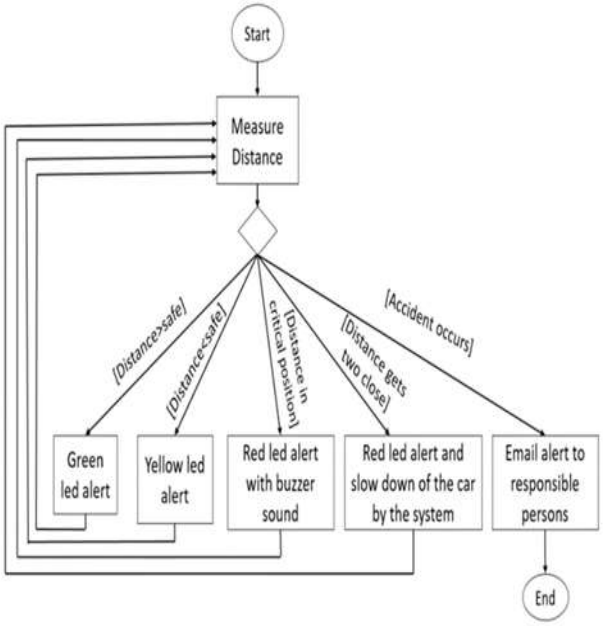

Fig. 1. Flowchart of the system.

The system is packed with AI-powered automation capabilities that can take over in situations when the distance between the cars is getting dangerously close and the driver doesn't pay attention to the alarms. It can reduce the vehicle's speed and crash danger right away by braking the car or changing the gearing. The

AI component of the system again kicks in in the terrible case of an accident. It streamlines the rescue procedure by sending the appropriate authorities an email notice with complete vehicle data. Several crucial parts make up the suggested system, including a Raspberry Pi, an ultrasonic sensor, LEDs, a buzzer, and a servo motor. Notably, our system integrates artificial intelligence (AI) inside the Raspberry Pi, allowing it to send email notifications without needing extra sensors, which makes the solution both effective and affordable. Figure 1 shows the flowchart of the system and figure 2 shows how the system works with a diagram.

3.1 WORKING OF THE SYSTEM

Below is an explanation of the conceptual model of our suggested system, which outlines its structure and behavior with an emphasis on the integration of Artificial Intelligence (AI) elements. Our system consists of a number of crucial parts that must be properly placed within the car. The front of the vehicle has an ultrasonic sensor, and if it has a manual gearbox, the gearbox has a servo motor linked to it. The servo motor is thoughtfully positioned next to the master cylinder, right next to the brake pedal, in automobiles with automatic transmissions. To ensure visibility and convenience of access, an interface is placed in the driver's line of sight, usually in front of the driver's seat. The system augmented by AI functions as follows:

a) Safety Indication: When a vehicle maintains a safe following distance from another, the system alerts the driver by lighting a green LED alert.

b) Attention: The system uses AI algorithms to determine the risk level when the space between cars closes. When the distance between the cars approaches a certain threshold, a yellow LED alarm turns on and a message appears on the interface. This warning is intended to serve as a safety measure for the motorist.

c) Danger Warning: The system sends out a more urgent alarm when the space between the cars continues to close, signaling an impending accident danger. A clear risk warning is given to the driver when a red LED light starts flashing and a buzzer sounds.

d) AI-Driven Automated Response: After issuing the danger alert, the AI component assumes control if the system doesn't hear from the driver and the critical distance continues. It starts the vehicle's slowing down by turning on the servo motor. This AI-powered functionality is a vital component of our system's safety.

Our system's use of AI enables dynamic and context-aware decision-making, guaranteeing that the alerts and vehicle modifications are made accurately and adaptably. This not only improves safety but also dramatically lowers the risk of accidents. Our suggested system's conceptual model integrates necessary hardware with AI-powered intelligence to efficiently monitor and react to the distance between cars. It offers a multi-tiered alarm system that, when necessary, culminates in AI-driven autonomous vehicle management, assuring traffic safety through immediate, context-sensitive decision-making.

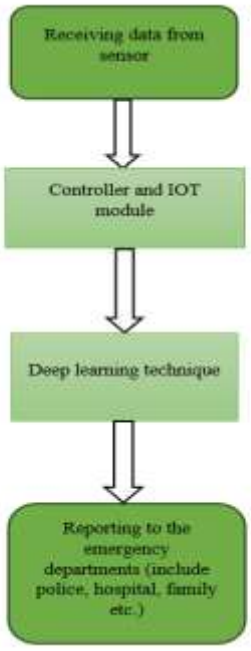

Fig. 2. Working of the system.

4. MERITS

a. Enhanced Road Safety: The system significantly improves road safety by actively monitoring vehicle distances and issuing timely alerts, helping to prevent accidents.

b. Automated Collision Prevention: Utilizing AI and servo motor control, the system can autonomously slow down the vehicle when a collision risk is detected, potentially avoiding accidents.

c. Driver Awareness: The system keeps drivers informed about the safe following distance through LED alerts and interface messages, promoting responsible driving behavior.

d. Quick Response: In the event of a critical risk, the system reacts swiftly with visual and auditory alerts, increasing the likelihood of driver intervention.

e. Reduction in Accidents: By addressing common causes of accidents like tailgating and failure to maintain a safe following distance, the system has the potential to reduce accident rates.

f. Efficiency: The system operates autonomously, requiring minimal user interaction, which can lead to safer driving without distracting the driver.

g. Cost-Effective: Utilizing a Raspberry Pi for email alerts makes the system cost-effective, making it accessible to a broader range of vehicles and users.

5. DEMERITS

a) Installation Complexity: Proper installation of the system components may require professional expertise, which could be challenging for some users.

b) Dependency on Sensors: The system relies on ultrasonic sensors, which may be affected by adverse weather conditions, dirt, or physical obstructions.

c) False Alerts: There is a possibility of false alerts, such as when overtaking another vehicle or driving on narrow roads, potentially leading to driver frustration or desensitization to alerts.

d) Limited Compatibility: Not all vehicles may be compatible with the system, particularly older models, which may lack the necessary interfaces for integration.

e) Maintenance: Regular maintenance and calibration of sensors and components are essential for the system to operate effectively, adding potential upkeep costs.

f) Driver Adaptation: Some drivers may find the constant alerts and automated vehicle control intrusive or uncomfortable, potentially leading to resistance in adopting the technology.

g) Privacy Concerns: The system collects and potentially shares data about driving behavior and vehicle details, raising privacy concerns that must be addressed.

6. Conclusion

Because the roads in the smart city are in such good shape, more incidents on the road come from drivers operating their cars at high speeds. several fatalities still happen despite the development of several accident detection and prevention techniques. At the very least, inadequate automatic accident identification, ineffective warning, and emergency service responses exacerbate a portion of the issue. A deep learning-based model is used in the second phase to evaluate the IoT model's output and carry out the rescue operation after an IoT kit is used in the first phase to discover the accident. The IoT module detects an accident and uploads all pertinent information to the cloud by utilizing a force sensor to assess the impact on the car and a GPS module to determine the speed of the vehicle. In order to lower the false detection rate and trigger the rescue module, pre-trained models, namely VGGNet and InceptionResNetV2, are used in the second phase. A rescue module is triggered and information is provided to the neighborhood police station, hospitals, and family members if the deep learning module identifies an accident. The proposed model can help us lower the number of fatalities caused by the lack of emergency personnel at the accident scene. Due to the combination of IoT and AI, the model has zero false positives during training and extremely low false positives during testing. We intend to address this issue in further work because the recommended model does not account for the security component. Some driver alert systems, such as the tiredness detection module, can also be included in the proposed model.

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