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TOWARDS ZERO ACCIDENTS: A SURVEY OF DETECTION AND PREVENTION SYSTEMS

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ABSTRACT

The increase in the number of vehicles being owned has resulted in a corresponding increase in road accidents, requiring the development of sophisticated methods for detecting and preventing accidents. This study provides a thorough examination of current technology and systems designed to reduce the consequences of road accidents. We analyze a diverse array of methodologies, including IoT-based systems, machine learning techniques, and sensor-based solutions. Although there have been notable advancements in accident detection, emergency response, and driver behavior analysis, there are still obstacles to overcome in terms of infrastructure, data protection, and practical use in real-world scenarios. The study highlights significant areas of research that have not been addressed and provides a clear plan for future research to improve the efficiency of accident detection and prevention systems. This article outlines the creation and use of a cutting-edge Automatic Speed Control System (ASCS) for cars, using up-to-the-minute geolocation data. The ultimate objective is to formulate all-encompassing approaches that use technology progress to provide safer conditions on roads.

Keywords: Smart Irrigation, Machine Learning, Internet of Things, Application

1. INTRODUCTION

The growing worldwide dependence on individual mobility has resulted in a significant rise in road congestion, hence increasing the occurrence of accidents and related deaths. The consequences of these incidents have wide-ranging effects that go beyond the immediate victims, affecting families, communities, and economies. In order to address this urgent problem, a focused endeavour has been made to create sophisticated systems for identifying and preventing accidents.

This paper presents a thorough examination of the most advanced technologies and systems used in accident detection and prevention. The study explores a wide range of methods, including those that use IoT, machine learning, and sensor-based techniques. The objective of this study is to discover significant patterns, difficulties, and prospects in the sector, offering important perspectives for scholars, policymakers, and industry players.

This study aims to enhance the development of accident detection and prevention techniques by analyzing the advantages and drawbacks of current options. The ultimate goal is to create a safer road environment by using technological and policy interventions in a careful and strategic manner.

The study is driven by the increasing need for cutting-edge technology that may improve road safety, optimize fuel consumption, and ensure adherence to speed laws. High-speed road accidents remain a major worldwide issue, sometimes worsened by unsuitable or excessive speeds. Current speed control systems have constraints when it comes to adjusting to changing environmental conditions and up-to-date geospatial data. Hence, the objective of this study is to tackle these difficulties by suggesting and executing a cutting-edge Automatic Speed Control System (ASCS) that utilizes geolocation data.

The current state of the automobile industry allows for the use of Global Positioning System (GPS) technology and intelligent control algorithms, which may be utilized to develop a speed control system that is more agile and adaptable. The ASCS utilizes geospatial data to analyze the vehicle's current location, road conditions, and local speed limitations in real-time. Based on this information, it dynamically adjusts the vehicle's speed to enhance both safety and efficiency.

The study is influenced by the growing focus on intelligent and interconnected automobiles. As automobiles become more connected with modern technology, it becomes clear that geolocation information may be used to enhance driving behavior. The planned ASCS is in line with the overall direction of the automobile industry towards intelligent transportation systems.

Moreover, the adoption of such a system has consequences not only for the safety of individual vehicles, but also for the wider social objectives of decreasing traffic accidents, mitigating environmental harm by enhancing fuel economy, and guaranteeing adherence to regulations. With the growing prevalence of autonomous and semi-autonomous driving technologies, the incorporation of geolocation-based speed control systems becomes more important.

2. RELATED WORK

The growing demand for automobiles [1] has resulted in an increase in road accidents and deaths caused by traffic congestion and communication problems. Automated accident detection systems using technology such as cell phones, ad-hoc networks, and GPS/GSM have the potential to save lives. Nevertheless, there are still obstacles to overcome, such as the need for enhanced communication infrastructure and the limits of detecting systems. Additional investigation and innovation are required to enhance rescue services and decrease the number of deaths.

An innovative technology based on the Internet of Things (IoT) [2] utilizes sensors installed on vehicles to identify and communicate accidents, enhancing rescue efforts via the automatic transmission of notifications to the relatives of the victims. In addition, the system includes a mobile application that allows eyewitnesses to submit reports manually. The efficacy of the evaluation is shown in a simulated setting, resulting in the preservation of human lives. Nevertheless, the system's efficacy in actual disaster scenarios, its dependency on internet access, possible privacy concerns, and the need on human reporting are all notable shortcomings. Integrating on a large scale with current emergency response systems may provide logistical difficulties.

The sleepiness and accident detection system [3] utilizes vibration, heartbeat, and eye flicker sensors, in conjunction with GPS and GSM technologies, to augment road safety. This device is capable of detecting accidents, notifying the driver's family, and continuously monitoring their status in real-time. The technology delivers prompt notifications and alerts to avert accidents and guarantee driver safety. Nevertheless, it could have constraints in precisely differentiating between typical and atypical driving circumstances, which might result in erroneous alerts. The efficacy of the eye flicker sensor may be contingent upon individual variations and ambient circumstances. Areas with inadequate network access may experience compromised reliability of GPS and GSM signals. Ensuring the precise operation of sensors requires calibration and maintenance. The ethical implications of privacy problems around biometric data and location information are significant.

A research study conducted in Saudi Arabia [4] seeks to tackle road traffic accidents by using an intelligent security framework and an Internet of Things (IoT)-based system to promptly identify accidents. The system employs Elliptic Curve Integrated Encryption and Message Queuing Telemetry Transport over GSM to promptly identify and communicate automobile accidents. The research emphasizes the versatility of the artifact for further applications in IoT security. However, it fails to tackle the unique difficulties encountered in practical situations, such as the efficacy in unfavourable weather conditions or distant locations, possible financial consequences, expandability for bigger networks, or obstacles related to user acceptability and adoption.

Research conducted on the Buraydah Ring Road in Saudi Arabia [5] shown that the implementation of speed cameras had a substantial impact on reducing the overall number of accidents, property damage, and injury-related incidents, while completely eliminating fatal accidents. The research classified 48% of segments as hotspots with medium or higher danger levels, which were effectively mitigated by the presence of speed cameras. Nevertheless, it should be noted that the results may not be generalizable to other road settings, and the study did not thoroughly investigate the ongoing viability and upkeep of speed cameras. The evaluation of the costs and benefits associated with the installation and upkeep of speed cameras was also overlooked. Additional investigation is required to evaluate the enduring efficacy of speed cameras and contemplate any alterations in driver conduct.

The article [6] presents a framework that utilizes Internet of Things (IoT) technology to identify and notify vehicle accidents in real-time. This framework integrates intelligent sensors, a microcontroller, GPS, and GSM technology. The objective of the system is to minimize the occurrence of reporting delays for accidents and the lack of availability of emergency assistance. Nevertheless, it encounters obstacles such as reliance on IoT infrastructure, the dependability of surrounding emergency services, concerns over privacy, difficulties with data security, power supply and maintenance, false alarms, and resistance from car makers and regulatory agencies in terms of adaption.

A system for detecting accidents based on the Internet of Things (IoT) [7] seeks to decrease road accidents and minimize delays in emergency response by incorporating intelligent sensors and a microcontroller into automobiles. The device utilizes vehicle tilt to identify accidents and promptly transmits position information over Wi-Fi to alert guardians for rapid aid. Nevertheless, the efficacy of the system can be influenced by the precision of the sensors, the possibility of false alarms, and the need for dependable Wi-Fi access. In addition, the system gives rise to worries over privacy and security, and the process of implementing and maintaining it might incur significant expenses and pose technological difficulties.

The surge in vehicular traffic [8] has resulted in a spike in accidents, requiring prompt and precise accident detection. This research presents a comparison between automated accident detection systems and conventional traffic center systems, highlighting the significance of using the former to decrease detection times and precisely identify locations. Nevertheless, automated methods may sometimes lack accuracy, entail significant upfront expenses, and depend on technology, rendering them vulnerable to glitches, inaccuracies, or cyber-attacks. The efficacy of distant or impoverished locations may be hindered by their limited access to infrastructure and technology. There are ethical problems that emerge with relation to privacy, data security, and the possibility for sensitive information to be misused.

Scientists [9] are working on creating perceptual video summarizing methods to visually represent accident information extracted from surveillance films. This method utilizes sub modularity to compress important frame summaries, and has shown potential in accident detection. Nevertheless, its capabilities are limited by the surveillance infrastructure now in place and the quality of the video footage. Additionally, it may encounter difficulties when dealing with intricate or busy environments and might potentially add computing complexity. Challenges include the need to modify the approach to suit various configurations and perspectives of surveillance cameras, while its efficacy in dealing with incidents that do not involve vehicles is not precisely specified.

The article [10] examines the use of consumer automobile sensors for the purpose of detecting roadworks, emphasizing their ability to be implemented on a big scale with minimum expenses. The research employs clustering and route reconstruction techniques to get elevated detection rates for roadworks on both expressways and non-expressway routes. The study highlights the need of shifting from point-based to route-based event detection for autonomous vehicle applications. The research also examines the distinctive characteristics of consumer car sensor data, such as the identification of yellow lane markings, in order to improve the capabilities of event recognition. Nevertheless, the research largely focuses on the identification of roadworks, which might result in overlooked detections or mistakes in reconstructing routes. Broader deployment and public adoption may face hurdles due to privacy concerns and scalability constraints.

An Internet of Things (IoT)-based system [11] has been created to identify and categorize accidents, with the goal of enhancing the speed of reaction after severe injuries. The system employs a microcontroller, GPS, sensors, and machine learning classifiers to identify and transmit accident information to emergency services. Factors like as g-force and fire incidence have a significant impact on the severity of accidents. Nevertheless, the efficiency of the system depends on the precise identification of physical factors associated with vehicle movement, which might prove to be difficult in real-life situations. The system's capacity to handle increasing demands may be restricted in rural regions with inadequate connection. The success of the system relies on its extensive acceptance and integration with pre-existing protocols and infrastructure. Additional validation is required to ensure wider applicability.

The Intelligent Transportation System (ITS) [12] is a tool for developing smart cities that utilizes wireless sensor networks and Internet of Things (IoT) technology to enhance public safety. The primary objective is to concentrate on the identification and examination of vehicles in accident notification systems, with a specific emphasis on high-risk regions like as construction zones. The system utilizes Arduino Mega 2560 and NodeMCU devices to compute distances between vehicles and evaluate the flow of traffic. The study suggests using Poisson's distribution methodology for statistical analysis in order to enhance precision. Nevertheless, the incorporation of these technologies may need specific expertise, and the dependability of the data relies on the precision of the sensors. Expanding the system to accommodate bigger cities may provide infrastructural and data management difficulties. Furthermore, it is essential to address issues about data privacy and security.

The study [13] proposes the use of RFID technology at building sites as a means to enhance safety. The system comprises RFID readers, semi-passive tags, and an IoT network, enabling the detection of entry/exit actions, the creation of dangerous zones, and the transmission of real-time alerts. The wireless data transfer is facilitated by using modern LoRa technology. Nevertheless, there are other possible drawbacks to consider, such as the upfront expenses for setting up, ongoing maintenance requirements, susceptibility to security risks, reliance on power supplies, and limits in terms of compatibility with current infrastructure.

A system using the Internet of Things (IoT) [14] has been created to identify and categorize car accidents. This system, referred to as the accident detection and classification (ADC) system, aims to enhance precision and minimize the time taken to notify incidents to emergency services. The technology utilizes the sensors of smartphones to identify and communicate various forms of accidents, therefore supplying crucial data for rescue efforts. The Naïve Bayes model got a commendable accuracy of 0.95 mean F1-score. Nevertheless, the system's performance may be constrained by its dependence on impaired or unreachable sensors, ambient variables, and restricted suitability for various vehicle kinds and models. Furthermore, the system's dependence on machine learning models necessitates ongoing upgrades and retraining. Concerns around privacy and the possibility for sensitive data to be misused are also present.

Annually, traffic accidents in the US result in around 6,000 fatalities and 400,000 injuries, with unfavourable weather and road conditions being a factor in 22% of these incidents. A potential solution to tackle these difficulties is an intelligent accident prevention system based on the Internet of Things. The system [15] utilizes an Internet of Things (IoT) framework to detect and analyze environmental factors, while using a machine learning algorithm to forecast optimal driving speeds for safety. Nonetheless, the efficiency of the system is contingent upon the precision and promptness of environmental data, the difficulties faced in implementing real-time operations, and the dependence on machine learning techniques. The performance of the system may also be constrained by the presence and extent of sensor networks in various places, and the implementation may encounter obstacles relating to expenses, infrastructure, and regulatory criteria.

The Deep Forests method, a Machine Learning tool [16], is being used to identify accidents and optimize the response procedure. The primary objective of this system is to streamline activities such as communicating with hospitals, alerting law enforcement agencies, and expediting insurance claims. Nevertheless, the use of sophisticated technology may include expenses, worries about privacy and data protection, and difficulties in effectively connecting different organizations such as hospitals, police stations, and insurance firms. These problems might potentially impact the efficacy of the system.

The automobile sector [17] is seeing substantial transformations as a result of the integration of multiple technologies and communication solutions brought about by the Internet of Things (IoT). A gadget has been created to notify hospitals in the event of automobile accidents, therefore improving the safety of drivers and passengers. The development is significantly enhanced by the use of IoT technology, which effectively decreases the time it takes to respond. Nevertheless, the efficacy of the device in distant regions, apprehensions about privacy, expenses, compatibility with outdated models, vulnerabilities to security breaches, and difficulties in achieving consistency among hospitals and emergency response systems all potentially hinder its success.

A smartphone sensor-based system [18] has been created to enhance the effectiveness of rescue operations in car accidents by recognizing and categorizing different sorts of accidents using Internet of Things (IoT) technology. The categorization of vehicle movement parameters is compared using machine learning methods such as Naïve Bayes, Gaussian mixture model, and decision tree. The Naïve Bayes model demonstrates exceptional accuracy, hence assisting emergency service providers in executing effective rescue operations. Nevertheless, the system's dependence on impaired or unreachable sensors might potentially restrict its efficiency. The performance of categorization models may vary depending on real-world accident conditions. The research also fails to address the issues of scalability and adaptation to various vehicle kinds and settings.

The study [19] describes an accident detection system designed specifically for motorcyclists. This system utilizes a tilt sensor and a GSM module to promptly transmit the precise position information to emergency contacts. The system achieves a detection rate of 97.33% and has undergone testing in real-world conditions. Nevertheless, the research fails to address the financial implications, the resilience in various conditions, and the small sample size of 10 bicycles in the study. Further implementation of comprehensive field testing and meticulous examination of both false positives and false negatives are necessary in order to achieve broader acceptance.

The article [20] introduces an advanced surveillance system for monitoring vehicle characteristics in order to enhance the safety of autonomous vehicles. The system utilizes a micro-controller to consistently monitor and record data logs, identifying accidents and collecting driving information before and after a collision. The primary objectives of the system are to enhance vehicle safety, facilitate collision investigations, and reduce the number of fatalities on the road. However, the efficacy of the system relies on the caliber and precision of sensors and alarm systems, issues about privacy, dependability in harsh environments, difficulties in integrating with current technology, and significant financial repercussions. The efficacy of real-time accident detection and emergency alerting is contingent upon the quality of network connection and the speed of reaction.

The research [21] presents a system based on the Internet of Things (IoT) that aims to enhance the efficiency of emergency response in road accidents. The system comprises a hardware component installed in cars and a web application designed for emergency services. Accidents are detected by sensors, which then transmit pertinent information to the online application. The efficacy of the system relies on the precision of the sensors and the durability of the hardware. Nevertheless, the usability of the device may be constrained in distant regions due to its need on internet access. The feasibility of the online application might be influenced by its usability. The system's dependability may be influenced by the expenses associated with its maintenance and repair.

The suggested system [22] intends to decrease the time it takes to respond to automobile accidents by including a hardware device that utilizes vibration and fire sensors to detect collisions and flames. The gadget establishes communication with a smartphone application using Zigbee Bluetooth technology, transmitting the GPS coordinates of the individual in need and their medical report to the closest hospital. The technology further verifies the availability of blood banks and sends messages when blood becomes accessible. Nevertheless, the efficiency of the system relies on the extent of network coverage, the compatibility of the device, and the timeliness of the driver or passenger after an accident.

An Indian research article [23] explores the use of GPS technology in automobiles as a means to decrease the number of deaths caused by road accidents. The system utilizes GPS and accelerometers to identify accidents and transmit location data to an Accidents Monitoring and Rescue Services Centre (AMRSC) using GSM. This data may be used to promptly notify rescue crews and perhaps prevent loss of life. Nevertheless, the system's dependence on GSM network may be constrained in regions with inadequate coverage, and its efficacy might be influenced by technological glitches, inefficiencies in rescue efforts, environmental obstacles, and privacy apprehensions. The expenses associated with implementing and upkeeping the system may present difficulties in achieving universal acceptance.

A suggested system [24] seeks to mitigate traffic accidents by promptly notifying authorities when a motorist is deemed incapable of operating a vehicle and by using GPS to provide the precise location of the accident. The technology identifies the presence of alcohol intake and tiredness, offering prompt aid after an accident. Nevertheless, the system may not reliably identify every case of driving impairment, and its efficacy is contingent upon drivers actually use the technology. The ongoing surveillance of the driver's state and whereabouts may give rise to issues over privacy. Other causative elements of accidents may not be acknowledged.

The research [25] use machine learning techniques like as Random Forest, LightGBM, and XGBoost to forecast the severity of automobile accidents by considering meteorological conditions. The analysis utilizes the comprehensive Countrywide Traffic Accident Dataset, which has a vast collection of 2.8 million traffic incidents that occurred in the United States between the years 2016 and 2021. LightGBM had the greatest level of predictive accuracy (72%), hence showcasing its potential in accident-avoidance systems. Nevertheless, the efficacy of the research may be influenced by distinct traffic and weather patterns, restricted data availability, and dependence on historical data. Moreover, the reliability of predictions may diminish in real-time situations as a result of unforeseeable road circumstances. The study's limited investigation of external variables may impact the applicability of the results.

An automotive accident alarm system, based on Arduino technology [26], has been created to mitigate the impact of human mistake in accidents. The technology employs GPS, GSM, and an accelerometer to identify abrupt changes in the vehicle's orientation and notify drivers via text messages. The primary objective of the system is to enhance road safety and mitigate the impact of accidents. Nonetheless, the efficiency of the system is contingent upon precise measurements obtained from the accelerometer, which might potentially be prone to inaccuracies or failures. The system's performance may be compromised by inadequate signal reception in distant regions or technological malfunctions. Users must assure the optimal operation and consistent upkeep of the system to guarantee dependability during critical circumstances.

The rising frequency of accidents resulting from inadequate safety precautions poses a substantial issue for authorities. An alternative approach [27] use Node MCU and sensors to regulate the duration of safety measures, with a specific emphasis on different accident kinds and their severity. Nevertheless, this method may be inaccessible or unreliable in some regions and may result in substantial expenses. Remote or rural places may have constraints in acquiring technology. The efficacy of the solution is contingent upon the precision and dependability of the sensors, while adherence to regulatory frameworks and standards may result in potential delays. The technique fails to mitigate the impact of human mistake in the interpretation of data.

A car accident detection and rescue system [28] using IoT technology, including GSM/GPRS, GPS modules, and vibration sensors, to identify accidents and establish communication with rescue personnel. Data is gathered and stored in real-time on a web server, and alerts are given using SMS, online applications, or Android mobile apps. Nevertheless, the system's efficacy might be compromised by inadequate network coverage, restricted GPS coverage, and the reliability of sensors and modules. Consistent upkeep and calibration of hardware components are essential for ensuring dependability and precision. The system gathers and retains sensitive information, necessitating strong steps to safeguard user confidentiality.

The growing demand for automobiles has resulted in an escalation in road accidents and deaths, mostly attributable to delays in the provision of emergency services. Automated road accident detection systems [29] are crucial for prompt assistance, using methods such as collision prediction utilizing cell phones, vehicular ad-hoc networks, GPS/GSM-based systems, and machine learning. The current approaches primarily concentrate on forecasting and averting accidents. However, the overview lacks precise statistical information, comprehensive insights into the efficacy and practical implementation of these systems, and a comparative evaluation of the methodologies. It would be advantageous to emphasize the economic ramifications and provide legislative suggestions in order to enhance road safety even further.

The Emergency Request Response and Management System (ERMS) is a research endeavor [30] with the objective of enhancing accident detection systems via the use of contemporary technologies. The technology employs vibration sensors and accelerometers to identify accidents and monitor intelligent ambulances. GPS is used for the purpose of deploying ambulances and informing the primary contacts of the victim. Nonetheless, the efficiency of the system might be impacted by the availability of internet and GPS connection, the capability to differentiate between real accidents and false alarms, possible technological glitches, and the need for substantial infrastructure investment. The effectiveness of the system is contingent upon the prompt reaction of authorities and specialists responsible for accident management.

The Internet of Things (IoT) has the capacity to enhance vehicle safety and fulfil customer requirements in the automobile industry [31]. Smart street lights have the capability to notify emergency services and minimize power wastage. Nevertheless, it is essential to address concerns about privacy, vulnerability to cyber-attacks, technological difficulties, and possible challenges related to energy usage. Deploying IoT technology in cars and infrastructure necessitates substantial investment in infrastructure and upkeep, particularly in distant regions.

The system employs RF technology [32] to alert drivers about road conditions and autonomously regulate their vehicle speed. The system comprises a Zone status transmitter and an Electronic Display and Control unit. The technology alerts drivers to decrease their speed according to the designated area, awaiting their acknowledgment. Nevertheless, the efficiency of the system might be influenced by variables like as interference, meteorological conditions, or hardware faults. The flexibility of the system may be

constrained in distant regions owing to insufficient infrastructure. The system's reaction may influence user compliance. Performing maintenance and upgrades may be expensive, particularly in locations with limited resources. New law or regulatory changes may also give rise to legal issues.

The objective of the project [33] is to address road accidents resulting from excessive speed in crucial areas by developing a speed limitation control system using GPS technology. The technology will autonomously modify the vehicle's speed to match the predetermined speed limitations. The efficacy of the system relies upon the precision and dependability of GPS, since any inaccuracies or discrepancies may result in erroneous speed modifications. The drivers' compliance with speed limits is essential, since resistance or technological faults may also be factors. Specific geographical areas may provide legal and regulatory obstacles, necessitating thorough examination and adherence to current legislation and norms.

The study [34] explores the need of implementing an automated vehicle speed control system in order to mitigate accidents in close proximity to schools, hospitals, and areas with abrupt turns. The system employs an Arduino Uno board and Zigbee wireless communication technology to deliver speed restriction signals to a receiver inside the car. This receiver, in turn, utilizes a speed encoder sensor to autonomously regulate the vehicle's speed. The use of this technology is anticipated to substantially decrease accidents and mitigate reckless driving conduct. The efficiency of the system relies on the constant operation of the Arduino Uno board, the range of Zigbee technology, external interference, the capacity to adjust to different vehicle kinds and models, and the drivers' compliance with speed control signals.

An innovative approach [35] seeks to mitigate road accidents by using RFID and GPS technologies into automobiles. The technology regulates the velocity of the vehicle according to the designated speed restrictions in specified areas, such as hospitals and schools. RFID readers detect and receive signals sent by neighboring RFID tags, therefore automatically modifying the speed of the vehicle. GPS data is used for speed control, including improvements for RFID tag security. Nevertheless, the system's efficacy could be limited in regions lacking RFID infrastructure, and there are difficulties in establishing uniformity in the placement of RFID tags and ensuring the accuracy of speed restriction data. The adoption of new technology may need substantial investment in both vehicles and infrastructure. Additionally, it is crucial to ensure compatibility with current technology and consider the possible effects on performance and driving experience.

The objective of the study [36] is to develop a prototype system for monitoring vehicle speed in remote areas. This system utilizes wireless sensors based on accelerometers, as well as GPS and Wi-Fi technology, to enable intelligent control of the vehicle. The system's objective is to guarantee secure velocities in crucial areas via the utilization of algorithms and the construction of code. The system has undergone simulation in a controlled laboratory setting, but, its efficacy in real-world scenarios has not yet been investigated. Integrating and synchronizing accelerometer, GPS, and Wi-Fi components might be challenging.

The prevalence of high speeds near crucial locations such as hospitals and schools are contributing to an increase in traffic accidents [37]. The existing solutions, like traffic rules and speed limiters, have not effectively resolved this problem. A forthcoming initiative seeks to deploy a GPS-based speed-limiting control system with the objective of augmenting road safety. Nevertheless, there are obstacles to overcome in terms of integrating the system with a wide range of cars, addressing driver acceptability problems, and dealing with possible opposition to automatic speed changes. Thorough testing and validation are necessary to guarantee the efficiency and security of the system.

The objective of the project [38] is to develop an automated speed control and accident-avoidance system using ultrasonic sensors. The sensors in question are responsible for monitoring the surrounding area of the vehicle and transmitting signals to an embedded board if impediments are spotted within a maximum distance of 4 meters. The device automatically modifies the speed of the vehicle and notifies the driver with an audible alarm. Nevertheless, the system's efficacy may be limited by environmental variables, such as inclement weather or road obstructions, and its capacity to precisely identify and react to diverse barriers. The system may also fail to consider abrupt moves by other cars, and its effectiveness may be restricted in areas with inconspicuous impediments.

Research conducted in Rwanda [39] devised a structural speed control and Internet of Things (IoT) enabled online monitoring system to tackle road traffic accidents resulting from excessive speeding. The system utilizes input and output pulse width modulation to direct the MOSFET controller, delivering electricity to the motor. The technique effectively decreases the voltage of the motor, hence enhancing safety. Nevertheless, the conclusions of the study may be limited to the particular field of inquiry and may not be generalizable to other geographical areas. The efficacy of the system relies on its compatibility and dependability.

An embedded system uses an Arduino microcontroller to regulate the velocity of a vehicle in accordance with its GPS coordinates [40]. The technology utilizes a GPS module and antenna to display the precise geographical coordinates of the car on an LCD screen. A gear motor modulates the velocity of the vehicle when entering a zone with speed restrictions, with the objective of mitigating the occurrence of accidents. The performance of the system may be influenced by the intensity of the GPS signal and many external conditions, which may impact its accuracy and dependability. Integrating the system into pre-existing cars may pose difficulties and incur high expenses, mostly owing to the need for connection with the Engine Control Unit and mechanical systems. Routine maintenance is essential for optimal performance.

A GPS-enabled gadget [41] has been created to regulate vehicle speed, with the goal of mitigating speeding and its consequences on road safety. The mechanism has been put in truck and bus engines to restrict speeds to 32 km/h in pedestrian zones, 58 km/h on highways, and 52 km/h on toll roads. Nevertheless, the system has constraints such as inconsistencies between GPS and map apps and difficulties in automatically adjusting speed limits.

An innovative approach [42] to enhance road safety is the use of GPS technology to construct an intelligent speed regulator. The system computes the velocity of the vehicle and automatically diminishes it if it exceeds the predetermined speed limit. An assessment using the System Usability Scale indicated a user satisfaction rating of 85.5%, which is considered high. Nevertheless, the precision of the device might be influenced by external variables and probable failures. It may also have difficulties with adapting to changing speed restrictions and gaining customer approval in real-life situations. Obstacles from drivers, police agencies, and legislative bodies may impede its widespread adoption.

The system, based on Arduino technology [43], automates the regulation of vehicle speed to enhance road safety, with a specific focus on metropolitan settings. Additionally, it has the capability to instantly measure a driver's blood alcohol content in order to avoid impairment. The technology also obeys traffic lights, hence decreasing the occurrence of accidents. Nevertheless, the efficacy of the system might be limited by the availability and precision of data, and it could not consider unexpected road conditions or abrupt barriers. Implementing this technology in all vehicles, regardless of the technical requirements, might pose significant challenges. The system's dependence on Arduino technology necessitates regular maintenance and is vulnerable to potential technological malfunctions.

The study [44] examines the use of GPS technology for the automated regulation of a vehicle's maximum speed, with the objective of enhancing safety in locations of high sensitivity such as school zones and hospitals. The technology comprises GPS navigation receivers, computer systems, map databases, speed sensors, and picture recognition. The algorithm checks the current position of the car with the highest speed limit allowed on the road, and then adjusts the speedometer appropriately. RFID technology is used in environments where GPS signal is restricted, while machine learning methods are utilized to enhance picture recognition capabilities. Nevertheless, the dependence on GPS signals may be restricted in places with dense coverage or underground, and the system's efficiency can be influenced by external circumstances.

The Real Time Automatic Speed Control Unit [45] utilizes mobile GPS technology to monitor and restrict vehicle speed, while incorporating both mechanical and electrical components. The device utilizes an infrared sensor to gauge velocity and use pulse width modulation (PWM) technology for control. The system exhibits little hardware complexity and underwent testing on an Arduino board. Nevertheless, it is dependent on the precision of GPS for speed limit information, has difficulties in assimilating into current automobiles, and is susceptible to external disruptions. Additionally, it may have constraints in severe weather or geographical circumstances and might encounter opposition from drivers.

The objective of the research [46] is to mitigate road accidents in India via the implementation of a complete speed regulation and area monitoring system. Notwithstanding the efforts of the administration, infractions continue to exist. The objective of the system is to regulate velocities in educational institutions, residential areas, and expressways, with a focus on enhancing road safety by mitigating human error. Nevertheless, there are other obstacles to overcome, such as dependence on technology infrastructure, possible opposition from drivers, inability to completely eliminate all accidents, financial expenses, potential system failures, and limited influence on external road safety issues such as vehicle maintenance or driver conduct.

A technique for predicting vehicle speed in real-time [47] is suggested, using a lightweight deep learning model that is powered by large amounts of temporal data. The approach dissects temporal data into a matrix of features and use an informer model equipped with an attention mechanism to acquire knowledge and make predictions. The experimental findings demonstrate a higher level of performance when compared to the most advanced approaches currently available. Nevertheless, the need for more assessment remains about the accuracy of forecasting driver conduct in response to the driving circumstances and the efficacy of autonomous vehicles in intricate or fast evolving driving settings. The scalability of the model for implementation across other vehicle kinds and driving circumstances is also evaluated.

The research [48] utilizes GPS and GSM technologies to provide emergency first aid services in traffic accidents. The GPS module monitors the precise position of the vehicle, transmits the geographical coordinates to the GSM system, and notifies the traffic control stations. The device further detects instances of exceeding speed limits. Nevertheless, there are some constraints to consider, such as the availability of GPS signal and network coverage in certain regions, as well as the possibility of accuracy problems caused by adverse weather conditions or erroneous GPS readings.

The objective of the research [49] is to regulate the speed of vehicles in sensitive locations by using RF technology to signal speed restriction zones. RF transmitters and receivers are positioned inside certain areas, and if the vehicle above the designated threshold, the system notifies the driver. Nevertheless, there are other constraints to consider, such as the possibility of signal interference, the reaction time of drivers, the availability of RF infrastructure, technical restrictions, the willingness of users to adopt the technology, and the legal and ethical implications.

The Smart Vehicle Over Speeding Detector system [50] utilizes Internet of Things (IoT) technology to identify and notify instances of cars exceeding the speed limit in designated areas such as educational institutions. An RF receiver transmits a signal to a microprocessor, which regulates the speed of the vehicle in order to avoid collisions. Nevertheless, the efficiency of the system relies on the dependability and scope of the RF transmitter and receiver, and may not readily adapt to changes in speed restrictions or regions that extend beyond schools. There are still concerns about privacy, enforcement, and the proper use of automated speed control technologies.

The research proposes an affordable method using GNSS technology [51] for monitoring vehicles in order to identify road segments where drivers surpass speed restrictions. Two instruments were created to quantify GPS velocity, and geographical data analysis revealed no notable disparity in the readings of speed. The gadget measurements closely approximated those of the car speedometer, especially when the vehicle was traveling at lower speeds. The research proposes modifying the speed restrictions set by law. Nevertheless, it may fail to consider various road and driving circumstances, the efficiency of the solution in congested or intricate road systems, issues about privacy, the influence of driver behavior, and the consequences of regulations and laws. Additional study is required to examine the scalability and long-term efficacy of the suggested approach.

Table 1: Summarization of Survey

Study	Technology	Objective	Benefits	Challenges
Automatic Accident Detection Systems	Smartphones, ad-hoc networks, GPS/GSM	Save lives through early detection	Potential to reduce fatalities and response times	Improved communication infrastructure, system limitations
IoT-based Accident Detection System	On-vehicle sensors, mobile app	Detect and report accidents, alert families	Automated alerts, improved rescue operations	Effectiveness in real accidents, internet dependency, privacy, manual reports, integration
Drowsiness and Accident Detection System	Vibration, heartbeat, eye flicker sensors, GPS/GSM	Detect accidents, alert family, monitor driver	Timely notifications, prevent accidents	Accuracy, false alarms, sensor reliability, privacy
Saudi Arabian IoT-based System	Elliptic Curve Encryption, Message Queuing Telemetry Transport	Immediate accident detection and reporting	Instant reporting, IoT security	Real-world challenges, cost, scalability, user acceptance
Speed Cameras	Speed cameras	Reduce accidents, property damage, fatalities	Significant reduction in accidents	Applicability to other environments, sustainability, cost-benefit analysis
IoT-based Accident Detection Framework	Smart sensors, microcontroller, GPS, GSM	Real-time accident detection and notification	Reduced reporting delays	IoT infrastructure, emergency service reliability, privacy, data security, power supply, false alarms, adaptation
IoT-based Accident Detection System	Smart sensors, microcontroller, Wi-Fi	Detect accidents, notify guardians	Reduced emergency response time	Sensor accuracy, false alarms, Wi-Fi reliability, privacy, cost, deployment
Automatic vs. Traditional Accident Detection	Comparison of systems	Improve detection time and accuracy	Faster response times, accurate location	Reliability, cost, technology dependence, infrastructure access, privacy
Perceptual Video Summarization	Surveillance videos	Visualize accident content	Efficient accident detection	Surveillance infrastructure, video quality, complex scenes, computational complexity
Consumer Vehicle Sensors for Roadworks Detection	Consumer vehicle sensors, clustering, route reconstruction	Detect roadworks	Large-scale deployment, low cost	Missed detections, inaccuracies, privacy, scalability
IoT-based Accident Detection and Classification	Microcontroller, GPS, sensors, machine learning	Detect and report accident details	Improved response time	Sensor accuracy, real-world challenges, scalability, adoption
Intelligent Transportation System (ITS)	Wireless sensor networks, IoT	Vehicle detection and analysis	Improved public safety in high-risk areas	Specialized knowledge, data reliability, scalability, privacy
RFID Technology in Construction Sites	RFID readers, semi-passive tags, IoT network	Detect entry/exit activities, create hazardous zones	Improved safety	Setup costs, maintenance, security, power sources, integration
IoT-based Automotive Accident Detection and Classification	Smartphone sensors, machine learning	Detect and report accident types	Improved accuracy, reduced reporting time	Sensor reliability, environmental factors, vehicle applicability, privacy
Internet of Things-based Intelligent Accident-Avoidance System	IoT system, machine learning	Predict safe speeds, avoid accidents	Address adverse weather and road conditions	Data accuracy, real-time implementation, sensor availability, cost, infrastructure
Deep Forests Algorithm	Machine Learning	Recognize accidents, streamline response	Simplified tasks, improved efficiency	Costs, privacy, data security, integration challenges
IoT-based Accident Alert Device	IoT technology	Alert hospitals in case of accidents	Enhanced driver and passenger safety	Remote area effectiveness, privacy, cost, compatibility, security, standardization

IoT-based Automotive Accident Detection and Classification	Smartphone sensors, machine learning	Detect and classify accident types	Improved rescue efficacy	Sensor reliability, classification accuracy, scalability, vehicle adaptability
Motorcycle Accident Detection System	Tilt sensor, GSM module	Detect accidents, send location information	High detection rate	Cost, robustness, sample size
Vehicle Parameter Monitoring System	Microcontroller, sensors	Detect accidents, gather driving information	Improved vehicle safety, crash investigations	Sensor quality, privacy, reliability, integration, cost, network connectivity
IoT-based Emergency Response System	Hardware subsystem, web application	Detect accidents, send information to emergency services	Improved response time	Sensor accuracy, hardware robustness, internet connectivity, web application usability, maintenance
Accident Detection and Rescue System	Vibration and fire sensors, smartphone app	Detect collisions and fires, send location and medical report	Reduced response time	Network coverage, device compatibility, driver/passenger response
GPS-based Accident Detection System	GPS, accelerometers, GSM	Detect accidents, send location to rescue services	Quick alert to rescue teams	GSM network coverage, technical issues, rescue operations efficiency, privacy, cost
Driver Impairment and Accident Detection System	Alcohol and drowsiness detection, GPS	Alert authorities, share accident location	Prevent accidents, provide assistance	Accuracy, privacy, other accident factors
Machine Learning for Accident Severity Prediction	Random Forest, LightGBM, XGBoost	Predict car accident severity	Accident-avoidance systems	Unique traffic and weather patterns, data limitations, real-time accuracy, external factors
Arduino-based Car Accident Alert System	GPS, GSM, accelerometer	Detect sudden shifts, alert drivers	Improved road safety	Accelerometer accuracy, signal reception, maintenance
Accident Prevention System	Node MCU, sensors	Control safety measures based on accident type and severity	Reduced accidents	Availability, cost, remote area limitations, sensor accuracy, regulatory challenges
IoT-based Vehicle Accident Detection and Rescue System	GSM/GPRS, GPS, vibration sensors	Detect accidents, communicate with rescue teams	Real-time data collection, notifications	Network coverage, GPS coverage, sensor stability, privacy
Automatic Road Accident Detection Systems	Smartphones, vehicular ad-hoc networks, GPS/GSM, machine learning	Predict and prevent accidents	Timely aid	Specific statistical data, effectiveness, real-world application, comparative analysis, economic implications, policy recommendations
Emergency Request Response and Management System (ERMS)	Vibration sensors, accelerometers, GPS	Detect accidents, track ambulances, notify contacts	Improved accident response	Internet and GPS connectivity, false alarms, technical malfunctions, infrastructure investment, authority response
Internet of Things (IoT) in Vehicle Safety	IoT technology	Improve vehicle safety, alert emergency services, reduce electricity waste	Consumer demands, public safety	Privacy, cyber-attacks, technical complexities, energy consumption, infrastructure investment
RF-based Vehicle Speed Control System	Zone status transmitter, Electronic Display and Control unit	Warn drivers, control vehicle speed	Reduced accidents in specific zones	Interference, weather conditions, hardware malfunctions, infrastructure, user compliance, maintenance, legal considerations
GPS-based Speed Limiting Control System	GPS technology	Automatically adjust vehicle speed	Reduced accidents in critical zones	GPS accuracy, driver willingness, technical malfunctions, legal and regulatory challenges
Automatic Vehicle Speed Control System	Arduino Uno, Zigbee	Control vehicle speed in specific zones	Reduced accidents, reckless driving	Arduino performance, Zigbee range, external interference, vehicle adaptability, driver compliance
RFID and GPS-based Speed Control System	RFID, GPS	Control vehicle speed based on zone speed limits	Reduced accidents	RFID infrastructure, speed limit data accuracy, investment, compatibility, performance impact
Accelerometer-based Wireless Sensor System	Accelerometer, GPS, Wi-Fi	Monitor vehicle speed, control in remote locations	Ensure safe speeds in critical zones	Sensor integration, real-world effectiveness, infrastructure

GPS-based Speed Limiting Control System	GPS technology	Control vehicle speed in critical areas	Improved road safety	Vehicle integration, driver acceptance, system testing
Ultrasonic Sensor-based Accident Avoidance System	Ultrasonic sensors, embedded board	Monitor vehicle space, adjust speed, alert driver	Reduced accidents	Environmental factors, obstacle detection, sudden maneuvers, detectability
Structural Speed Control and IoT-based Monitoring System	Input and output pulse width modulation	Reduce motor voltage, increase safety	Reduced accidents in specific area	Applicability to other regions, system compatibility, reliability
Arduino-based Speed Control System	Arduino microcontroller, GPS module, gear motor	Control vehicle speed in speed-restricted zones	Reduced accidents	GPS signal strength, environmental factors, vehicle integration, maintenance
GPS-Triggered Speed Control Device	GPS technology	Control vehicle speed in specific areas	Reduced speeding	GPS and map discrepancies, automatic speed limit adjustment
Smart Speed Governor	GPS	Calculate vehicle speed, automatically reduce if over limit	Improved road safety	Environmental factors, malfunctions, dynamic speed limits, user acceptance, enforcement
Arduino-based Speed Control and Alcohol Detection System	Arduino, GPS, alcohol sensor	Control vehicle speed, detect alcohol level	Improved road safety, prevent intoxication	Data availability, accuracy, unforeseen road conditions, technical failures
GPS-based Automatic Speed Control System	GPS navigation receivers, computer systems, map databases, speed sensors, image recognition	Control vehicle speed in sensitive areas	Improved safety	GPS signal limitations, external factors
Real Time Automatic Speed Control Unit	Mobile GPS, IR sensor, PWM technique	Monitor vehicle speed, limit speed	Reduced accidents	GPS accuracy, vehicle integration, external interference, weather conditions, driver resistance
Comprehensive Speed Control and Area Monitoring System	GPS, speed control mechanisms	Control speeds in schools, residential zones, highways	Reduced accidents	Technological infrastructure, driver resistance, system malfunctions, financial costs
Real-Time Vehicle Speed Prediction Method	Deep learning model, temporal data	Predict vehicle speed	Improved accident prevention	Driver behavior prediction, complex driving environments, scalability
GPS and GSM-based Emergency First Aid Service	GPS, GSM	Track vehicle location, alert traffic control stations	Emergency response	GPS signal and network coverage, accuracy
RF-based Speed Limit Warning System	RF transmitters and receivers	Warn drivers about speed limits	Reduced speeding	accuracy

3. CONCLUSION

The rising incidence of road accidents, propelled by the growing number of vehicles and associated variables, highlights the immediate need for strong accident detection and prevention technologies. Although there have been notable advancements in the development of technologies such as the Internet of Things (IoT), machine learning, and sensor-based solutions, there are still difficulties in areas like as infrastructure, data protection, and practical use in real-world scenarios.

The Research results suggest a significant link between the use of sophisticated technology and a decrease in both accident rates and mortality. Systems with the ability to identify and notify in real-time, as well as respond to emergencies efficiently, have great potential. Nevertheless, the effective implementation of these systems requires a comprehensive methodology that takes into account variables like as network dependability, data confidentiality, and societal approval.

In order to properly tackle the intricate problem of road accidents, a comprehensive approach is necessary. This encompasses ongoing research and advancement in accident detection technology, the creation of strong and reliable infrastructure, strict restrictions on data protection, and extensive public education on road safety. Through promoting cooperation among academics, politicians, and industry stakeholders, it is feasible to provide a more secure road environment for everyone.

Subsequent investigations should prioritize the advancement of accident detection systems with enhanced precision and dependability. Additionally, there is a need to investigate novel approaches to ensure data privacy and security. Furthermore, it is crucial to conduct thorough assessments of system performance under various real-world circumstances. The ultimate objective is to reduce the human and economic impact of road accidents by implementing technological and policy interventions effectively.

CONFLICT OF INTERESTS

None.

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