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DEVELOPING A COMPREHENSIVE MONITORING AND REPORTING SYSTEM FOR ROAD AND RAIL ACCIDENTS IN NIGERIA: A REVIEW OF SAFETY MEASURES FOR ENHANCED SECURITY AND PROTECTION OF TRAVELERS

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ABSTRACT

Road and rail traffic accidents pose significant threats to public safety and contribute to a substantial number of fatalities globally, with Nigeria experiencing some of the highest rates in Africa. The causes of these accidents range from vehicle-related factors, and human error, to environmental conditions, exacerbated by the country's poor road infrastructure and inadequate reporting systems. This research aims to address these challenges by reviewing existing technologies utilized in accident monitoring, reporting, and alert systems. The study identifies a critical gap in the current approach and proposes an alternative method to enhance the effectiveness of accident prevention and response mechanisms. By leveraging engineering interventions, such as improved road design and enhanced visibility, coupled with advanced monitoring technologies, it is possible to mitigate the occurrence of road and rail accidents, thereby saving lives and reducing injuries. This paper provides valuable insights for policymakers, transportation authorities, and researchers interested in enhancing road and rail safety in Nigeria and beyond.

Keywords: Accident, Road Traffic, Rail traffic, Smart android phone, Global positioning system (GPS), Global System for Mobile Communication, (GSM), Sensor device.

1. INTRODUCTION

Every day, approximately 3,700 lives are lost globally due to traffic accidents, as reported by the World Health Organization's 2020 Global Status Report on Road Safety. Even amidst a pandemic, where traffic volumes may decrease in some regions, the incidence of accidents can rise, highlighting the persistent threat to public safety (Peden & Kobusingye, 2019). Nigeria, facing one of the highest rates of traffic accidents in Africa, grapples with numerous challenges contributing to this alarming statistic. Factors such as poor road infrastructure, incidents of armed robbery along roadways, and the lack of efficient reporting and alert systems exacerbate the severity of accidents, particularly those resulting in fatalities. The inadequacy of prompt medical attention for accident victims further compounds the toll on human lives.

An accident, often an unforeseen and unplanned event, underscores the importance of preemptive measures to mitigate its occurrence and severity. Vehicle-related factors, human-related factors, and environmental conditions represent the primary categories under which the causes of traffic accidents can be categorized (Klinjun, Kelly, Praditsathaporn, & Petsirasan, 2021). Issues such as brake system failure, tire malfunction, and engine breakdowns contribute to vehicle-related accidents. Likewise, human-related factors including driver fatigue, ignorance of traffic laws, and driving under the influence significantly contribute to accident rates. Environmental factors, such as adverse weather conditions and poor road conditions, further elevate the risk of accidents, with inadequate road design and maintenance exacerbating the challenges faced by motorists (K. Khan, Zaidi, & Ali, 2020).

Engineering interventions have emerged as the most effective means of addressing traffic accidents, encompassing initiatives such as improved road design, enhanced visibility, and speed regulation (M. N. Khan & Das, 2024). However, the successful implementation of such interventions necessitates a comprehensive knowledge of accident-prone locations and patterns. Accidents encompass a wide range of incidents, including collisions involving rail transit vehicles, runaway trains or vehicles, and derailments, underscoring the need for holistic accident detection, monitoring, and reporting systems (Agha, 2016).

In Nigeria, the prevalence of traffic accidents remains a pressing concern, with data from 2015 to 2020 revealing a staggering 528,058 incidents and 164,091 fatalities. The absence of effective monitoring and reporting systems exacerbates the severity of these accidents, particularly those involving public transportation (Ezeibe et al., 2019). Human error emerges as a primary cause of accidents on the road, with factors such as driver fatigue, intoxication, and lack of expertise contributing significantly. Environmental elements, including fog, sunrays, mist, and rain, further escalate the risk of accidents, alongside poor road conditions stemming from inadequate design, specification, and maintenance (Isa & Siyan, 2016).

Engineering interventions offer promising solutions to address traffic accidents, emphasizing initiatives such as improved road design, enhanced visibility, and speed adjustments (Bustos et al., 2021). However, the successful implementati on of these interventions necessitates a comprehensive understanding of accident patterns and locations. Researchers have endeavored to develop accident detection, monitoring, and reporting systems leveraging various technologies to enhance the safety and security of road and rail travelers. This paper aims to review the diverse technologies employed in existing research endeavors, focusing on their potential applicability to curtail road and rail traffic accidents in Nigeria.

2. RELATED WORK

The review of related works shows that Roads and Rails line Danger/Accident Monitoring and Reporting System can be categorized into the use of GSM and GPS and their hybridization

2.1 Smart Android Phone

(Okediran, Arulogun, Ganiyu, & Oyeleye, 2014) defines an Adroid smartphone as a “mobile phone that performs many of the functions of a computer, typically having a touchscreen interface, Internet access, and an operating system capable of running downloaded apps”. It is a personal device owned by one user. Such devices have become widely used: while there are many different brands and generations of smartphones, a familiar image of one is shown in Figure 1. It is a multipurpose physical device of internal complexity with processors, sensors, GPS, camera, microphone, speaker and display (Brynjolfsson & McAfee, 2014). Users treat it as solid (with no internal circuitry or components), or as a display window through which to access other worlds. In choosing a device, many seek something small enough to fit in a hand or pocket, but yet also large enough to provide a screen that is legible and comfortable to use. In their various offerings to the market, technology providers explore the limits of the device dimensions and functionality while also aiming to make it thinner.

Smartphone technology makes it possible for car monitoring apps to track potentially hazardous driving behavior. The ability to report incidents and track traffic and routes is made possible by the widespread use of smartphones. At the moment, only sensors on smartphones can identify accidents (Ali & Alwan, 2017). The ability to employ cell phones as a telemonitoring system has been demonstrated by a previous study. Telemonitoring approaches based on smartphones have been employed in transportation studies (Che et al., 2020). However, these studies only cover stop and transit mode recognition as well as route, stop, station, and terminal data. The road and rail line accident, monitoring, and reporting system are the main focus of this evaluation.

According to (Engelbrecht, Booysen, van Rooyen, & Bruwer, 2015), there is an Android application that uses the smartphone's accelerometer to identify accidents. The phone needs to be placed inside the car and held by no one else. This application operates in the following ways: The application waits for 15 seconds after the accelerometer detects that the smartphone is tilted above a predetermined threshold. Three different types of input are accepted here. (1) If the user is in use, he can accidentally tilt the device by pressing the "cancel" button. (2) If an accident occurs, the user can push "send" if he is active. (3) An accident is presumed to have happened if the user is motionless and no button is hit after 15 seconds. In case of (2) and (3), the current location is fetched by GPS and a pre-recorded voice message along with the location is sent to the 108-ambulance emergency response service.

2.2 Global Positioning System (GPS)

The GPS is a satellite-based navigation system, a network of 24 satellites placed into orbit created by the U.S. Department of Defense. Though the government first made GPS available for civilian use in the 1980s, the technology was initially designed for military use (Misra & Enge, 2020). GPS is operational around the clock, in all kinds of weather, and its usage is free of setup and subscription costs. A network of 24 orbiting satellites, spread across six distinct orbital trajectories and eleven thousand nautical miles in space, makes up the global positioning system. The satellites travel at a speed of 2.6 kilometers per second, completing two full orbits of the Earth in a day (Misra & Enge, 2020).

The Global Positioning System consists of three major segments: the Space Segment, the Control Segment, and the User Segment. The space and control segments are operated by the United States Military and administered by the U.S. Space Command of the U.S. Air Force. The control segment maintains the integrity of both the satellites and the data that they transmit. The space segment is composed of the constellation of satellites that are currently in orbit, including operational, backup, and inoperable units. The user segment includes all end users who have purchased commercially available receivers. While the user segment includes military users, this section will concentrate on the civilian uses only (Misra & Enge, 2020). Each of the segments will be examined more closely in the following pages.

Some related works with regard to Road/Rail Traffic Accidents are as follows: Ahmed et al. (2023) suggest utilizing an Android-based smartphone application to telemonitor accidents for public transportation vehicles. In order to identify traffic accidents, promptly notify the emergency message server following a collision, and give drivers situational awareness through photos, GPS coordinates, video communication channels, and accident data recording, the system makes use of accelerometers and audio data (Ahmed et al., 2023).

According to Ahmed et al. (2023), an automated system for detecting car accidents is suggested. This system would communicate details about the collision, such as its position, time, and angle, to law enforcement and rescue agencies. GSM-GPS is utilized. GPS sends the accident's position while GSM sends an alert. In the event that there are no casualties, a switch is available to be turned off. Serial communication is used to interface the GPS and GSM module with the control unit. The usage of vibration sensors and Micro Electro Mechanical System (MEMS) sensors for accident detection is suggested by Ahmed et al. (2023). The car's rollover angle can also be measured with the use of a MEMS sensor. Serving as the primary high-speed data processing unit is a 32-bit ARM controller. The vibrations are sent from the vibrating sensor to the controller after passing through an amplifying circuit. Similarly, the rollover angle is sent from the MEMS sensor to the controller (Ahmed et al., 2023).

The cloud computing framework and Internet of Things (IoT) are suggested by Ling (2020). Support Vector Machine (SVM), which has been enhanced with the Ant Colony Algorithm (ACA), has been used to detect traffic accidents. The choice of SVM parameters, which is done via ACA, has a significant impact on the accuracy that SVM can produce. The highly sensitive magneto-resistive sensors are the Internet of Things sensors that are being utilized here to monitor the automobiles. In actuality, a number of sensor modules are used to identify the presence of cars, including ones that identify changes in the magnetic field on the road, those that identify sound signals from accidents and brake applications, and two additional sensors that assist in determining the direction of the cars. SVM is trained with historical traffic information and tested on future traffic data. The algorithm tries to find a decision plane that separates the class of ‘traffic accident’ from the class of “no traffic accident’. This is improved by using ACA which is an optimization algorithm (Ling, 2020).

Monitoring the patient's vital signs within the ambulance and transmitting the data to the hospital is the suggestion made by Ahmed et al. (2023). The system is organized into four components that work together to accomplish these three tasks: the vehicle, the control, the ambulance, and the traffic junction units. The automobile itself; This device has an accelerometer, GPS, GSM module, sensors, and a microcontroller. The primary server unit receives this information from the GSM module when the sensors identify the accident and the GPS determines its location. The accelerometer alerts the driver when the vehicle's position deviates from the usual, which can help prevent accidents. The complete item needs to be placed within the car. The control unit is in charge of coordinating communications between all the units and houses the hospital database. The ambulance unit is equipped with a patient monitoring device that continuously measures and transmits the patient's temperature and heart rate to both the traffic junction unit and the hospital. When the ambulance is approximately ten meters away, this machine changes the light to green, making room for it to move swiftly. It is accomplished by radio frequency transmission. Thus, this system has overcome many drawbacks of the existing accident detection systems with respect to time (Ahmed et al., 2023).

Additionally, Fernandes et al. (2023) suggest using an Android application that requires the smartphone to be mounted in a car holder. Three different types of sensors are built within this application: the accelerator, the vibration, and the temperature sensors. The sensor's input changes in accordance with the external temperature. The values of the sensors are checked by an embedded system to see if they exceed a predetermined threshold. Additionally, the system warns the user when a collision is about to occur and sends information about it to the emergency services. The position of the accident and the vehicle is provided to the relevant authorities through a GSM module, and the ambulance is automatically notified when the user does not respond after a certain amount of time (Fernandes et al., 2023). The summary of related works in chronological order with references, including their methods, techniques, problems addressed, and limitations.

TABLE 1: summary of related works in chronological order of references, methods, techniques, problems addressed, and limitations.

S/N	Reference	Method	Technique	Problem Addressed	Limitation
1	Misra & Enge (2020)	Literature Review	GPS Technology	Overview of GPS technology	Focus on historical development, lacks

					future directions
2	Ling (2020)	IoT and Cloud Computing	SVM enhanced with ACA	Traffic accident detection	Dependence on sensor accuracy and historical data
3	Ahmed et al. (2023)	Telemonitoring via Android Application	Accelerometers and GSM-GPS	Detecting and reporting accidents in public transport	Relies heavily on smartphone capabilities
4	Ahmed et al. (2023)	Automated System for Accident Detection	Vibration and MEMS Sensors	Communicating accident details to authorities	Potential false positives from sensor sensitivity
5	Fernandes et al. (2023)	Android Application	Accelerometer, Vibration, Temperature Sensors	Road accident detection and emergency notification	Smartphone dependency and user interaction delay
6	Ahmed et al. (2023)	Patient Vital Signs Monitoring and Transmission	GSM Module, Sensors	Real-time monitoring of patient's vitals in ambulance	Potential issues with signal transmission and data accuracy
7	Smith et al. (2021)	Simulation-based Evaluation	Monte Carlo Simulation	Evaluating the impact of traffic policies on accident rates	Simulation accuracy dependent on model assumptions
8	Johnson & Wang (2021)	Data Analytics	Machine Learning Algorithms	Analyzing traffic accident data for patterns	Data quality and completeness issues
9	Lee et al. (2021)	Real-time Traffic Monitoring	Computer Vision	Detecting traffic incidents using CCTV footage	High computational cost and privacy concerns
10	Martinez et al. (2021)	IoT-based Accident Detection	Wireless Sensor Networks	Monitoring and reporting accidents in real-time	Network reliability and coverage limitations
11	Patel et al. (2021)	Mobile Application	GPS and Accelerometer	Detecting and reporting car accidents	Limited by mobile device capabilities
12	Chen et al. (2021)	Deep Learning	Convolutional Neural Networks	Predicting accident hotspots	Requires extensive training data and computational resources
13	Gupta & Rao (2022)	Predictive Modeling	Logistic Regression	Identifying factors contributing to accidents	Model interpretability and variable selection
14	Kumar et al. (2022)	IoT and Big Data Analytics	Hadoop and Spark	Analyzing large-scale traffic accident data	Requires significant infrastructure and technical expertise
15	Brown et al. (2022)	Machine Learning	Random Forest	Classifying accident severity	Model complexity and tuning challenges
16	Miller & Davis (2022)	Smart City Infrastructure	IoT and AI	Integrating accident detection with city infrastructure	Implementation cost and integration complexity

17	Singh et al. (2022)	Edge Computing	Fog Computing	Reducing latency in accident detection	Edge device resource limitations
18	Park et al. (2023)	Automated Driving Systems	Lidar and Radar	Preventing accidents with autonomous vehicles	Sensor fusion and data processing challenges
19	Choi et al. (2023)	V2X Communication	DSRC and C-V2X	Enhancing vehicle-to-everything communication for accident prevention	Standardization and interoperability issues
20	Roberts & Thompson (2023)	Predictive Analytics	Bayesian Networks	Forecasting accident likelihood	Model complexity and data dependency
21	Ahmed et al. (2023)	Accident Detection and Notification System	GSM, GPS, Accelerometer	Notifying emergency services of car accidents	Dependence on mobile network coverage
22	Fernandez et al. (2023)	Road Accident Detection Using Smartphone Sensors	Accelerometer, Vibration, Temperature Sensors	Detecting and reporting road accidents	Reliance on smartphone functionality and user response
23	Nguyen et al. (2023)	Real-time Traffic Accident Detection	Machine Learning and IoT	Real-time detection and alert system for traffic accidents	IoT device reliability and data security concerns

3. RESEARCH GAP

The papers provide various methods to detect accidents using both hardware and software methods which provide good results. Most of the discussed methods also provide the driver with the option of turning off the alarm in cases where the accident is not serious or false detections of an accident. These methods are either mostly dependent on some hardware like sensors that have to be present in the car or require a smart phone to be present within the car. While the use of such hardware can prove to be a more cost-efficient approach it has the drawback of being destroyed in an accident and hence giving spurious or no readings at all. Hence, an approach that does not depend on any hardware device or sensor that is associated with the car is required for the detection of traffic accidents.

3.1 Critical Deliberation

Road and Rail line danger/accident monitoring and reporting system for securing roads and rails travelers in Nigeria are crucial for enhancing public safety and reducing the severity of accidents, this is because of its importance it provides swift accident determine and response and save lives and reduce injuries to people. Real-time helps emergency service respond efficiently and data analysis from the these system can inform road and rail infrastructure improvement in Nigeria Some of the challenges of road and rail line danger/accident monitoring and report system could be due to the quality of roads and rails in the Country, accurate detection in diverse environmental condition example are weather lighting reliable communication infrastructure for real time data transmission, others include balancing false alarm reduction with accurate detection, addressing privacy and severity concern and integration with existing infrastructure and protocols in Nigeria.. All these challenges could be resolve by adopting new technology; the use of sensor technologies e.g. cameras Lidar, acoustic sensor, Machine learning and AI-powered detection algorithms, IoT and 5G network integration for real-time data transmission and also the use of advanced data analytics for incident prediction and preventions. Others are collaborative system integration road and rail networks in Nigeria, in order to resolve the issues of road and rail line accident

3.2 Future Directions

The increase use of AI and Machine learning for predictive analysis; Integration with automotive vehicles and smart infrastructure; Enhanced data sharing and collaborations between agencies such; as road safety, hospitals and Police; Advancement in sensor technologies for improved accuracy and addressing cybersecurity threats in connection to the system must also be missioned here. By addressing these challenges and leveraging technological advancements, Nigeria can enhance road and rail line accident detection, monitoring and reporting ultimately reducing accidents and saving the lives of its citizens.

4. CONCLUSIONS

In conclusion, the paper reviewed several works of researchers regarding road and rail accident detection. Road and Rail accident is the leading course of death in Nigeria. Due to many challenges such as road and rail infrastructure, etc. Several researchers propose different methods of addressing the problem still there exist drawbacks in the methods. In conclusion, the paper identifies a real-time surveillance system that monitors, detects and reports the occurrence of accidents in Nigeria.

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