

A Review of Road Accidents Detection through Wireless Technology—5G, MIMO and Internet of Things

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Abstract

Road transport is been used for moving people and all kinds of goods throughout the world. However, it is one mode of transportation that is prone to accidents and it faces a plethora of never-ending challenges, such as the frequent loss of lives and valuables when accident occurs. The best course of action to handle these issues is to set up an autonomous incident detection system using wireless communication, 5G technologies and the Internet of Things. IoT is a seamless technology that increases the connectivity between humans and machines. It is web-based, and improves communication between vehicle to vehicle, vehicle to infrastructures, transfer of data and information to predict incident occurrences through various networks and frameworks such as eCall, OneM2M and integration of mobile broadband. Additionally, internet of things is being adopted for public safety; for instance, it can speed up first responders' response times to situations by displaying the best routes to a scene of an accident. The rapid development of 5G is happening in parallel with developments of internet of things (IoT), artificial intelligence (AI), and smart platforms for novel applications such as mission-critical communications. 5G is a new generation technology that operates on the Ultra High Spectrum Band UHSB. It is an innovation that uses the pedestrians-vehicle-road-cloud, and the communication between vehicle locations and temperature of high-quality connection. It is essential for intelligent transport systems because it allows for information sharing, prediction of incidences as safety is the primary concern of road transport. This review examines accident detection through 5G technology, integrated mobile broadband, and multiple inputs multiple outputs (MIMO) wireless system. Finally, we conclude by examining recent technology, challenges, present and

future research trends.

Keywords

5G, Internet of Thing (IoT), Wireless Communication, Technology, Road Transportation

1. Introduction

Road transport systems is been used across the world. The advantage of this in the 21st century is that technological inventions and innovation are at the peak and this will aid accident detection if properly applied by the professionals and road users. A work presented in [1] utilizes an ultrasonic sensor to find accidents on the road, while some others rely on a smart phone's infrared sensor. Some modern techniques exist for automatically identifying traffic incidents and have presently been used. There are multiple ideas for various automatic accident warning systems in the scientific literature. Among these are various machine learning approaches, mobile applications, the Global System for Mobile Communications (GSM) and Global Positioning System (GPS), vehicle ad hoc networks, and others [2], also the use of Optical wireless communication referred to as OWC, without relying on radio frequency (RF)-based wireless technologies, OWC can compete in future communication networks like 5G and 6G systems. Due to its extensive spectrum coverage, high data throughput, and low latency, its solutions are unique in the 5G and other related industries. The internet of things, a cutting-edge new network technology, connects everything as presented in [3].

As a result, this study explores road accident detection through wireless technology—5G and Internet of things. The paper suggests novel methods for rapid detection, eCalls, OneM2M, Unmanned Aerial Vehicle, through 5G ultra high spectrum band UHSB and Multiple Input and Multiple Output (MIMO). The main contribution of this study is to provide the novel method on how technology will detect an accident and notify the appropriate authorities. The remaining part of this paper is structured as follows, Section 2, presents the review of related studies. Section 3 examines the scenarios of incident occurrences through various IoT networks. Section 4 presents detection of accident occurrences through 5G technology. The Conclusion is provided in Section 5.

2. Related Works with Similar Characteristics of Road Accident Detections

Safety is the main priority of the transport industry and threat of road accident cannot be over emphasized, also the use of technology to reduce these challenges is of utmost importance. Building automatic systems to identify traffic accidents and shortening the time between an accident happening and the deployment of

first responders to the scene are two effective ways to lower the number of traffic fatalities. Recent methods employ the built-in automatic accident detection and reporting system of vehicles [4]. The main importance of in-built automatic accident detectors in vehicles is that they will not depend on humans before they trigger an alert to the requisite authority. The quality of the functionality of the system is to be built and preinstalled in the vehicle and they are perfectly serviced and properly maintained, for effective prompt and accurate timing and location as shown in **Figure 1**, the detection and notification will be transmitted when an accident occurs.

Another study in [5] expressed that the main cause of accidents is speed. It is known that speed is one of the leading causes of car accidents, and the design of IoT is the system that can identify accidents quickly and send the information to the first aid centre and the safety personnel. Many lives could have been saved if emergency personnel had access to the accident information in a timely manner.

In [6], an application for car alarms using an accelerometer to detect unsafe driving was introduced. During an accident or right after one, it is employed as a crash or rollover detector vehicle. The signal used to identify the serious accident is received by an accelerometer. In this study, the vibration sensor will detect the signal and send it to the ATMEGA 8A controller when a vehicle is involved in an accident or rolls over. Since technology is improving daily, emergency services must be redesigned using cutting-edge technology [7].

The downside of the technology is that they are the expensive to maintain for proper effectiveness. The use of wireless technology will increase the detection and emergency services.

The collision avoidance system is another wireless communication system that could be employ in detecting road accident and rescue operation as the work presented in [8], studied several literatures on collision avoidance techniques, that it was introduced with particular emphasis on communication issues in the context of automotive cyber-physical systems advocate using affective computing and affective emotions, together with a brand-new taxonomy, to comprehend VCPS principles.

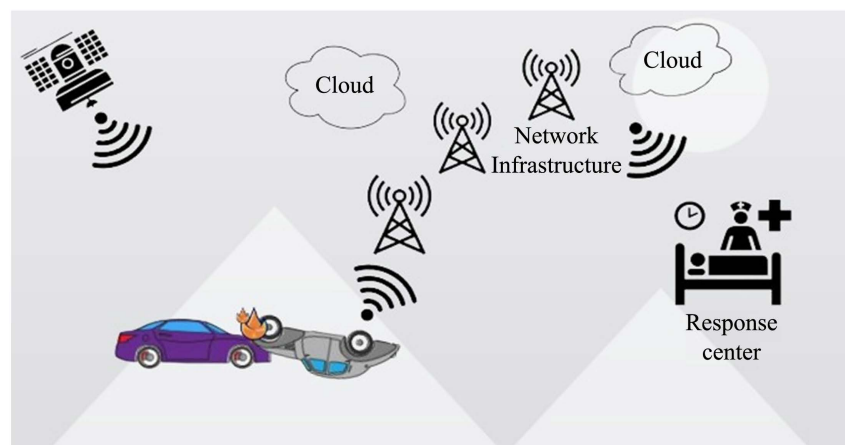


Figure 1. Accident detection and reporting.

The issue of accident detection cannot be over emphasis, as safety is the priority of the industry and the effectiveness of wireless communication technology will aid the immediate responsiveness and accuracy to detect accidents. **Table 1** gives the review of some existing works in the literature.

3. Detection Incident Occurrences through IoT Various Networks

Internet of things (IoT) has been improved over the century to effectively detect accidents on the road and the main goal of using IoT is to accurately connect to the first responder when accidents occur. Once the IoT detect the occurrence of an accident, the activation will be spontaneous using network of interconnected device either human to machine or machine to machine. The authors in expressed that internet of things (IoT) is a network of connected computing devices, items, animals, or people that are given unique identifiers and the capacity to communicate data over a network without requiring human-to-human or human-to-computer interaction. It is physical components that can collect and share electronic information that make up a network.

The IoT framework helps in the quick detection and notification of car accidents. This can be done by combining intelligent sensors with a microcontroller

Table 1. Review of existing schemes findings.

Ref	Accident Detections	Limitations	Performance Measures	Simulators
[1]	Ultrasonic detector.	Limitation of processors on various devices.	Works effectively in a variety of street scenarios as well as in a wide range of natural conditions.	Infrared sensors (IR sensors), smart phones, airbags, and mobile applications.
[9]	Footage from security cameras placed on roads and highways that would suggest the possibility of a vehicle accident.	The method cannot identify vehicles that are so severely damaged that none of the vehicle parts under consideration are present.	Offers encouraging results when evaluated on two separate datasets of damaged cars, which vary in terms of the image's quality, its proximity to the camera, and the amount of items in the image.	Damaged Cars Dataset-1 (DCD-1) and Damaged Cars Dataset-2 (DCD-2).
[10]	IoT system model-GMM and CART.	Requires constant Internet access.	Improved in terms of recall and precision.	G-force, rollover, fall-off, rollover, fire, accident location, and speed.
[11]	Intelligent traffic light system.	GSM messaging's queue-based system's delay.	Fully automated.	GSM messaging.
[6]	Accelerometer in car alarm application.	Internet stuttering and lost GSM during an accident.	Vibration sensor with increased sensitivity and accuracy.	GSM texting. GPS and an MCU ATmega 8A.
[12]	Accelerometer for micro-electromechanical systems with an ultrasonic sensor.	Not used in all cases.	Take immediate action and act quickly to save the victim's life.	Many protocols for connectivity, including cellular, LoRaWAN, and NB-IoT.

built into the car that can activate during an accident, by identifying accidents in time and summoning emergency personnel right away, this system can resolve the majority of accident cases by adding the aforementioned functionalities [13]. [14], the author described that there are various systems categorize and networks that can be used for accident detection and quick responses in the event of an accident using wireless technology, IOT, and 5G to identify accidents detection and thereby to reduce accidents. Therefore, the method by which IoT devices exchange data involves some pre-processing, which comprises changing the format of records and their classification that will be transform into information transmitted to the various station for detection of accident, fatalities, and injuries. The details of how incident occurrence will be predicted using different networks are provided in the sections below.

3.1. eCall (Electronic Call)

An eCall system's primary function is autonomous detection of car accidents and the subsequent notification of the emergency services, saving lives or decreasing the severity of injuries by communicating vital information to the responders, and drastically shortening their reaction time [15].

As shown in **Figure 2**, when a serious traffic collision happens, eCall is an emergency call that can be made manually by passengers in a car or automatically by the activation of in-vehicle sensors. The in-vehicle eCall system makes a direct 112-voice link with the appropriate Public Safety Answering Point when it is engaged (PSAP) [16].

In the event of an accident, the eCall system, an in-vehicle call system, opens the channel for communication over GSM/CDMA, and the Vehicular Network will trigger the following occurrence the eCall System. Airbag deployment or the starting of the fuel pump shutoff can be used to determine an accident [17]. Another study explained that an intelligent algorithm is created to determine the accident's kind and scene. An emergency voice call is placed to the operator from the car following an accident. The operator can access an SMS that contains the data mentioned in the aforementioned sections if the passengers of the

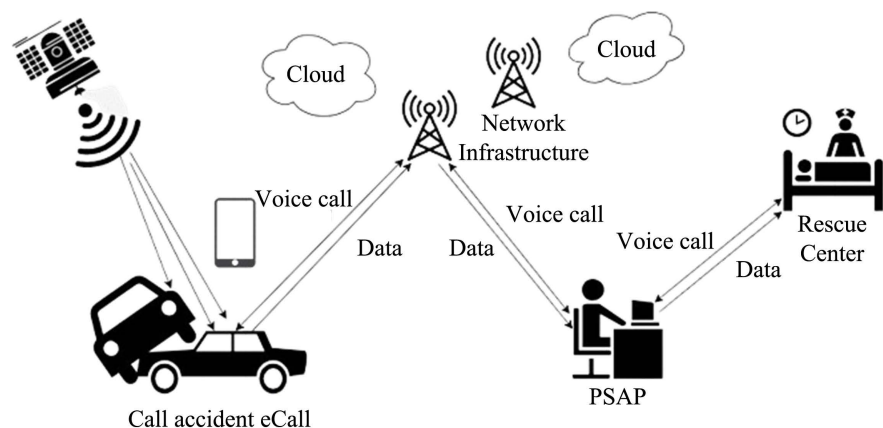


Figure 2. Electronic call for accident detection.

automobile don't respond. The operator can take the obligatory actions to send the required rescue forces in accordance with the information collected. SMS can include additional details than the data gathered by the sensor, like the owner's name, the type of car, and the license plate.

3.2. OneM2M

Road safety could be greatly enhanced by machine-to-machine (M2M) connectivity and the utilization of big data produced by M2M communication [18]. It should be noted that IoT can be integrated to monitor alerts for automatic accidents. According to the proposed system, every vehicle must be equipped with an M2M device in its on-board unit. This unit oversees locating accidents, determining their severity, and using wireless technology to report accident events to an M2M server application. Furthermore, using lightweight M2M standards protocols makes the M2M server in charge of allocating the required resources for the rescue operation and disseminating the knowledge to other M2M devices to give the victims a better chance and resources for survival [19]. However, human factors have an impact on the reasons why accidents happen in traffic. The main causes of this include driver illnesses like fatigue, sleepiness, and other chronic disorders. The internet of things (IoT) technology was developed to address these problems.

This framework model refers to the IoT oneM2M standard. Consequently, it might be able to communicate with other programs or systems to detect accident and proper measured will be used to contact the appropriate authorities such as the rescue authority and hospital facilities [20].

3.3. Unmanned Aerial Vehicle

Real-time accident detection is another significant aspect in road transport, the use of UAV such as drones will be extremely beneficial in emergency services, including firefighting as well as other emergency services, where the connectivity of AI will enable 5G and 6G network nodes to recognize an accident in real time. In [7], accident detection devices send out an emergency alert after detecting the accident. Eventually, the drone picks up the signal and precisely locates its target. The mishap could be trivial or serious. However, timely emergency rescue assistance is required. Drones will thus arrive at the intended location on time and disperse medical assistance. It will also transmit video to control centres and medical facilities as shown in **Figure 3**.

4. Accident Detection through 5G

5th generation has been the technology that can be effectively used to detect accident and allow effective communication. The authors in [21] proposed that, 5G communication is advancing road transportation with its remarkable communication speed, which is redefining the networking concept. It is important to leverage 5G technology curb the high rate of fatalities and injuries caused by accident.

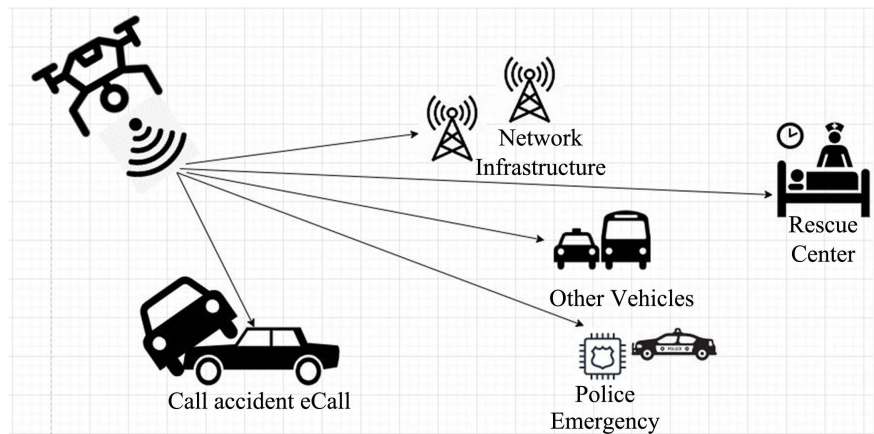


Figure 3. Unmanned aerial vehicle to transmit to the control centre and facilities.

4.1. Integration of Mobile Broadband

In [22] the authors concentrated on the prediction of 5G and the significant challenges in the future of mobile networks, as well as the difficulties the mobile network provider is currently experiencing to reduce the traffic demand and detection of accident for mobile broadband in the years to come. It also demonstrates that 5G will offer a zero-latency access data rate similar to that of fibre. Although there are several accident detection technologies, the death rate is still rising. The slow reaction to catastrophic accidents is due to inaccurate accident detection and subpar communication techniques. Traffic management systems often employ automatic or non-automatic methods to identify incidents. Processes for automatic incident detection (AID), which employ a variety of sensors and techniques including image processing, are more often used. Additionally, research is done on vehicle probes that analyse traffic data to swiftly identify incidents and detector/sensor-based event detection algorithms [23].

A new age in mobile wireless communication technology will be ushered in by 5G network technology. The terminal should be able to mix different flows from different wireless technologies since the 5G devices will have simultaneous access to several wireless technologies [24].

With IMT-Advanced (IMT-A) systems already in use, 5th-Generation (5G) mobile communication technologies are now entering the research stage. 5G will also be able to provide intelligent optimization based on services and user awareness and will improve energy and cost efficiency by over a hundred times, allowing us to all realize the vision of 5G, “information a finger away, everything in touch” [22].

The term “smart transportation” refers to a transportation system that, with the use of a network infrastructure, provides increased production, safety, and efficiency. One of the primary enabling technologies for such smart transportation systems is 5G in combination with AI algorithms. Under the umbrella of a dedicated transportation network with high security, high performance, and cloud computing, connected cars and RSUs will provide services of collision prevention and route optimization [25].

4.2. Accident Detection through Multiple Inputs and Multiple Outputs (MIMO)

MIMO is a technology that is needed to detect accident and aid quick response transmission method. It uses several antennas for both transmission and reception of detection of road accident. MIMO technology allows for simultaneous data transfer, which provides an effective data rate. More transmission and reception can be done if there are more antennas [24]. It is also an array antenna technology is a very promising field with a lot of promise for use in 5G systems. Several Input Multiple Output (MIMO) systems use multiple antennas to send and receive data using this method. Massive MIMO systems are especially made to prevent interference between users and between cells, leading to improved throughput and increased dependability [26], with the array of antenna used in the configuration of MIMO, it can be used to detect accident when they occur. However, the configuration of MIMO efficiency is largely depend on the use of extensive antenna to be able to detect accident and communicates to rescue centre.

MIMO will make a difference as postulated by the author in [27], that the use of millimetre-wave (mmWave) massive multiple-input multiple-output (MIMO) technology to facilitate gigabits-per-second (Gbps) communication for cellular vehicle-to-infrastructure scenarios was adopted. As a fundamental component, the authors characterise the mmWave massive MIMO vehicular channel using metrics such as path loss, root-mean-square delay spread. The idea of a global infrastructure of networked physical goods, allowing connectivity for anything, anywhere, at any time, has sparked interest in the Internet of Things (IoT). To handle the massive increase in traffic for 5G, mm-Wave frequencies, dense base stations (small dense cells), and spectacular antennas are required. In this work, all the three technologies—massive MIMO, millimetres-wave, and dense small networks—worked well together, enabling the development of IoT applications on 5G networks. Massive MIMO offers interference suppression and spatial multiplexing, thereby providing high array gain while simultaneously reducing total transmit power by deploying a large number of antennas that use very low transmit power, a strategy that lowers total transmit power while increasing array gain. Dense small cells and mm-Wave also play important roles in enabling IoT applications to be integrated into 5G networks [3].

Several other papers have also examined the issues of 5G and 4G technology. In [28]-[33], machine learning predictive models for path loss modelling of 4G networks was introduced. Accurate characterisation of path loss will go a long way in providing stability as it relates to signal propagation in 5G networks. For accident detection in road transport system using 5G technology will be appropriate to achieve quality, reliable signals.

5. Conclusion

This work has reviewed the role of technology in detection of accidents and the

effective frameworks to communicate to the appropriate rescue personnel. While several researches suggested other coherent frameworks, this study is centred on the IoT and 5G. The framework, which includes eCalls, UAV, OneM2M, MIMO, and the integration of mobile broadband, would make accident detection and communication more reliable and effective, hence lowering the number of fatalities and injuries. However, while improvements in wireless technology over the coming years may bring us closer to an accident-free road, they won't necessarily eliminate accident occurrences and fatalities.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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