



A Comprehensive Survey of Accident Detection Methods and Their Progression

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Abstract: Worldwide, road traffic crashes continue to claim a large number of lives and cause massive economic damage. A major factor that determines survival chances is how quickly emergency services are informed after an incident. Over the past few decades, accident detection techniques have evolved from purely manual reporting to advanced automated solutions that rely on IoT devices, various sensors, computer vision, and artificial intelligence. This survey reviews the historical development, current approaches, and future trends in accident detection and notification systems, including human-dependent methods, sensor-based systems, smartphone applications, Intelligent Transportation Systems (ITS), and AI-enhanced frameworks. A comparative study reveals that modern solutions significantly outperform traditional ones by reducing response time and increasing detection accuracy. The paper concludes with remaining challenges and promising research directions for next-generation systems.

Keywords: Accelerometer, Detection, Emergency Response, IoT, Raspberry Pi, Sensors, Smart Mobility

I. INTRODUCTION

Road accidents rank among the most severe global issues of this century. In fact, the global statistics show that every year, millions of people are injured, and a sizable fraction of the deaths is due to the delayed emergency response. Thus, with the increasing number of vehicles worldwide and the growing urban areas, the role of quick scene recognition in the accident chain of events is of major importance to the survival rate in a casualty. Normally, accidents are reported when a witness or a driver informs the police or calls an ambulance, however, the reaction time under these conditions is still very slow in places far from the cities and during the night. Studies have shown that even one-minute reduction in accident detection time can lead to the increase of the chances of survival by almost 6 percent [2].

In order to move away from the dependence on manual intervention in accident detection, scholars have come up with an array of methods over the years. They started off with threshold-based mechanical sensors and have now moved to complex IoT-supported architectural designs, high-tech image-processing systems, and AI-powered predictive algorithms. On top of that, the Intelligence Transportation Systems (ITS) evolution has embraced the use of the road sensors, CCTV surveillance, and the vehicle-to-infrastructure (V2I) communication for fast incident detection [4], [9].

This article traces back the history of accident detection from the very first human-intervention-based methods till the contemporary IoT and AI technologies, presenting various solutions that have been implemented over the years for comparison purposes. The work done in this field and the present condition of this issue are summarized. Among other issues, the paper mainly discusses the problem, which deals with accuracy, response time, deployment cost, and scalability.

II. RESEARCH BACKGROUND

Researchers have proposed numerous accident detection mechanisms tailored to different environments, vehicle types, and communication frameworks.

Aishwarya et al. [11] introduced an IoT-based system combining accident tracking with drowsiness detection for night drivers, improving prevention and early identification. Sadhana et al. [12] developed a smart helmet for motorcyclists for those wanting safety while integrating the Raspberry Pi and the OpenCV module. Namrata et al. [13] built a GPS-GSM-based device which allows the detection of the accident and location tracking in real time. Later, Bhavthankar and Sayyed [14] developed a proposal for a wireless reporting system using accelerometers. Finally, Krishna Priya et al. [16] introduced a vehicular accident detection and tracking system through IoT, and Arun Francis et al. [17] solely presented a driver alerting system as well.



While the sophisticated ITS advancement is in the context of perceptual video summarization [4], sensor fusion, Bluetooth scanning [7], GPS trace analysis [8], and V2I communication [6] improved detection methods; traditional traffic monitoring systems experienced challenges that suggested limits in larger expressway networks where human reporting is still the primary source [21].

Modern automatic detection approaches significantly overcome these hurdles by enabling continuous, accurate, and autonomous monitoring.

III. INCENTIVE BEHIND THE STUDY

Road accidents cause significant loss of life and injuries every year, and many fatalities occur not because help is unavailable, but because it arrives too late. When accidents happen in isolated areas or without witnesses, emergency services are notified only after human intervention causing long delays. Such fast, almost-. automatic, accident locating makes the whole thing both very efficient and absolutely necessary. An idea which resulted in the creation of the systems was the need to lower the response time, which would in turn increase the survival rates and also decrease the frequency of cases where the human factor is involved in the reporting of the incident. The automated detection also guarantees that the exact location is the first to receive the signal, thus allowing for quick medical intervention and general public safety. The first versions of the technologies for accident detection have undergone changes along different phases, depending on their technological basis.

A. Early Human-Based Detection

In the past, the detection of accidents was mainly based on human reports, which could be made through emergency hotlines, police notifications, or communications from people who happened to be at the scene [9]. Despite its simplicity, this approach is quite slow and unreliable, particularly in low-traffic areas or at night. The waiting time results in increased numbers of people who lose their lives, secondary accidents, as well as the inefficient dispatch of emergency services.

B. Threshold- Based Sensor Systems

Animators and vibration sensors for mechanical parts that detect the occurrence of road accidents were already in use in the first electronic solutions.

They are still good for city settings but cannot be trusted on country roads.

These systems functioned on the preset threshold logic and were widely used due to the low cost. However, they were constrained by high false- positive rates on uneven roads or during abrupt braking [14].

C. GPS-GSM Based IoT Systems

With the rise of IoT, accident detection shifted toward integrated sensor modules that collect the data and automatically transmit alerts with precise GPS coordinates. GSM is the basis of the communication backbone. Studies report notable reductions in alert latency using such systems [16], [20].

D. Smartphone-Based Solutions

Many works leverage built-in smartphone sensors- accelerometer, gyroscope and GPS to detect crashes. While widely accessible, these systems are limited by battery constraints, device-orientation, and network availability. They are still good for city settings but cannot be trusted on country roads.

E. Intelligent Transportation Systems (ITS)

CCTV, AID algorithms, AVI/AVL systems, and traffic detectors are the main components of the ITS infrastructures [4], [8], [21]. These systems offer continuous monitoring but are limited by high deployment and maintenance costs. Coverage constraints create blind spots where incidents may remain undetected for long durations. Thereby such systems allow to tackle these blind spots.

F. Machine Learning and AI-Enhanced Systems

Recent research explores machine learning models trained on motion signals and video data to differentiate real collisions from non-critical movements [5], [10]. The mentioned systems exhibit high accuracy and reduce false positives, but it requires extensive training datasets and computational resources.

IV. COMPARATIVE ANALYSIS

The ways of recognising accidents have changed profoundly over time, which in turn has resulted in a broad range of techniques from which those of different strengths and weaknesses can be distinguished. There is a comparative analysis



of the major categories presented below that take into account parameters such as accuracy, response time, cost, coverage, automation, and false-positive rate.

A. Human-Based Reporting vs. Automated Systems

The Traditional detection has as its mainstay the humans: either the eyewitnesses, the police patrols, or the vehicles passing by that can report an accident.

Advantages: There is no need for a technological infrastructure.

Limitations: There is hardly any reporting during night-time, rural roads, or low-traffic zones; human error can be made; it depends on whether there are witnesses by chance.

Alternatively, the automatic systems that resort to IoT, sensors, or AI are able to detect and alert instantly, and no human intervention is needed.

Strength: The response time and consistency are greatly improved which is a huge step forward.

Weakness: Hardware or network access is indispensable.

Sum-up: The automation of the detection process has made it possible to locate the events much more quickly and in a more trustworthy manner, which is the major problem of the traditional ways of doing things that is solved here.

B. Threshold-Based Sensor Systems vs. Multi-Sensor Approaches

A simple accelerometer-based system can recognize a crash if the g-force it is programmed to detect is exceeded.

Advantages: Cheap, simple to implement, little computer power required.

Limitations: Sensitive to road surface and sudden braking; high false recognition rate.

Different sensors on a device can get better crash recognition using an accelerometer, gyroscope, and GPS.

Advantages: Can differentiate between harsh braking, road irregularities, and true collisions; improved precision.

Limitations: Higher hardware cost and slightly increased complexity.

Sum-up : Threshold-based methods are cheap but cannot be trusted; multi-sensor fusion is the preferred option for real-world applications.

C. Smartphone-Based Detection vs. Dedicated IoT Modules Section Headings

Smartphone-based systems use built-in sensors (accelerometer, gyroscope), GPS, and mobile data.

Advantages: No new hardware is needed; can be used almost everywhere.

Limitations: Depend on battery, user carrying the phone, orientation, and network coverage.

Dedicated IoT modules mounted in vehicles operate continuously.

Advantages: Reliable, always powered, consistent data collection.

Limitations: Needs to be set up; medium price.

Sum-up: Smartphones are handy but not very reliable in highways and remote areas, whereas IoT modules ensure performance in different environments.

D. ITS (CCTV, Radar, Traffic Centres) vs. In-Vehicle Detection

Intelligent Transportation Systems use roadside hardware- CCTV, radar, and traffic centres for monitoring.

Advantages: Wide-area monitoring, centralized oversight, integration with traffic control systems.

Limitations: Very expensive, limited coverage, blind spots, dependence on operators, and significant maintenance costs.

Accident detection devices in vehicles identify accidents that happen in the vehicle itself.

Advantages: Fastest detection, not affected by environmental conditions or availability of staff in the control centre.

Limitations: Only in equipped vehicles.

Sum-up: ITS is very efficient in urban areas; however, in-vehicle systems are better regarding the speed of response and being independent of the external infrastructure.

E. GSM/SMS Alerting vs. IoT/Cloud-Based Communication

The systems of previous generations generate alerts via GSM SMS.

Advantages: Easy and can be done by anyone.

Limitations: Message transmission is slow; there can be delays between different stages in the network; there is a limitation on the number of characters which the message can contain.

An IoT/cloud-based system communicates through MQTT or HTTP APIs.

Advantages: Quick, dependable, real-time tracking is available, unlimited by the number of users.

Limitations: Needs to be connected to the internet.

Sum-up: IoT/cloud communication is far better when it comes to speed and scalability than just SMS.

F. Machine Learning-Based vs. Rule-Based Detection

Rule-based detection systems operate through certain limits and conditional statements that are pre-set.



Advantages: Easy to implement and requires little computation power.

Limitations: Can hardly be improved; a lot of false alarms; cannot take into account the context.

The machine learning model identifies the crash patterns by examining the data (sudden spikes in the impact force, rotational change, vibration profiles).

Advantages: High precision, can adjust itself as it goes, low number of false alarms.

Sum-up: ML-based detection is a major step towards dependable detection; however, it necessitates more advanced technology.

The comparison vividly demonstrates that advanced IoT and AI-powered systems deliver far better performance than the old methods in nearly all aspects, most notably in accuracy, automation, and response time.

Traditional methods remain useful but are insufficient for ensuring timely emergency intervention. Multi-sensor IoT devices and machine learning models represent the most promising direction for robust, scalable, and real-time accident detection.

TABLE I
COMPARITIVE ANALYSIS

Method	Accuracy	Response Time	Cost	Automation	Limitations
Human Reporting	Very Low	Slow	None	No	Delay, human error
Threshold Sensors	Low Medium	Fast	Low	Partial	High false positives
Multi-Sensor Fusion	High	Fast	Medium	High	Requires Hardware
Smartphone-Based	Medium	Medium	Low	Medium	Battery/orientation issues
ITS Infrastructure	Medium-High	Medium	Very High	Medium	Limited coverage
IoT Modules	High	Very Fast	Medium	High	Network-dependent
Machine Learning	Very High	Fast	Medium-High	High	Data+computation needed

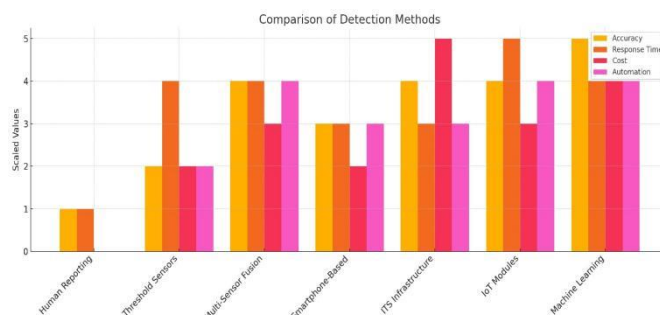


Fig. 1 Comparison of Detection Methods

V. OBJECTIVES- BASED OUTCOME

The comparative review shows that modern accident detection systems provide substantial technical improvements over earlier approaches. Automated IoT-based and multi-sensor architectures demonstrate significantly faster detection and alert transmission when compared to traditional human-reported methods. Essentially, the systems that are always operating and recognize automotive collision accident sites in a spontaneous fashion and respond to those incidents are the best response systems to real time events as they do not require human input which, unfortunately, must be applied in such situations especially in private areas with no transit or low human traffic.

In addition, the study notes that the least complex threshold-based accelerometer systems which are more cost effective are less reliable as they are influenced by road surfaces and suddenly stop no impact vehicle movements.

Conversely, devices that compile sensor data of accelerometer, gyroscope and GPS for a stabilized signal as they can operate on numerous variables at the same time are more reliable as there are less false positives and event differentiation



is more appropriate. Communication efficiency reveals very significant differences between older GSM based alerting devices with the newer IoT/cloud based one. Internet based protocols enable information transmission at a higher speed and since tracking is always plausible, they are more easily integrated into emergency systems which allow final recipients to gain alerts at quicker speeds.

Furthermore, detection systems based on machine learning processes have reinforced system performance as such models learn patterns of motion where thresholds are not needed. Such models always achieve higher accuracy and better proficiency within varied driving conditions so there is a strong likelihood that misclassification and noise concern will be diminished.

Ultimately, the results indicate that technologically advanced systems based on IoT, multi-sensor fusion and ML have greater functional performance-related capacities due to detection accuracy, real time response, communication efficiency, operational reliability and thus, these systems are the most effective solution for accident detection at this time.

VI. CONCLUSION

One of the major changes in accident detection systems is the passage of time. Initially, reporting methods relying on humans were slow and could make mistakes, thus, increasing death rates. Nowadays, IoT, sensor fusion, ITS, and AI-based methods have considerably improved detection accuracies and shortened alert times. However, there are still challenges such as limited coverage, high costs, and dependence on the network.

Future research should mainly revolve around hybrid architectures combining IoT, V2X communication, cloud intelligence, and sensor fusion to be able to deliver continuous and reliable detection in various environments. Enhancing interoperability and reducing deployment challenges will be instrumental in making safer roads accessible everywhere in the world and in efficient emergency responses.

REFERENCES

- [1]. A. Zanella, N. Bui, A. Castellani, L. Vangelista, and M. Zorzi, "Internet of Things for Smart Cities," *IEEE Internet of Things Journal*, vol. 1, no. 1, pp. 22–32, Feb. 2018.
- [2]. I. Khan and S. Sawant, "IJARCCE A Review on Integration of Cloud Computing and Internet of Things," *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 5, 2016.
- [3]. S. Sharma and S. Sebastian, "IoT based car accident detection and notification algorithm for general road accidents," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 9, no. 5, p. 4020, Oct. 2019.
- [4]. S. S. Thomas, S. Gupta, and V. K. Subramanian, "Event Detection on Roads Using Perceptual Video Summarization," *IEEE Transactions on Intelligent Transportation Systems*, vol. 19, no. 9, pp. 2944–2954, Sep. 2018.
- [5]. Z. Zhang, "Traffic Event Detection from Consumer Vehicle Sensor Data: An Autonomous Vehicle Study," *Transportation Research Record: Journal of the Transportation Research Board*, p. 036119812211050, Jul. 2022.
- [6]. V.-T. Ta and A. Dvir, "A secure road traffic congestion detection and notification concept based on V2I communications," *Vehicular Communications*, p. 100283, Aug. 2020.
- [7]. A. Bhaskar and E. Chung, "Fundamental understanding on the use of Bluetooth scanner as a complementary transport data," *Transportation Research Part C: Emerging Technologies*, vol. 37, pp. 42–72, Dec. 2013.
- [8]. E. D'Andrea and F. Marcelloni, "Detection of traffic congestion and incidents from GPS trace analysis," *Expert Systems with Applications*, vol. 73, pp. 43–56, May 2017.
- [9]. K. Zhang and Jalil Kianfar, "An Automatic Incident Detection Method for a Vehicle-to-Infrastructure Communication Environment: Case Study of Interstate 64 in Missouri," *Sensors*, vol. 22, no. 23, pp. 9197–9197, Nov. 2022.
- [10]. M. Ozbayoglu, G. Kucukayan, and E. Dogdu, "A real-time autonomous highway accident detection model based on big data processing and computational intelligence," *2016 IEEE International Conference on Big Data (Big Data)*, Dec. 2016.
- [11]. A. Rai and Charitha, "An IoT Based Accident Prevention & Tracking System for Night Drivers," *International Journal of Innovative Research in Computer and Communication Engineering (An ISO)*, vol. 3297, 2007.
- [12]. A. Santoso, "Irjet-V3I3I28 - Smart Helmet for Motorcyclist Safety Using Raspberry Pi," *Studocu*, Jun. 02, 2023.
- [13]. N. H. Sane, D. S. Patil, S. D. Thakare and A. V. Rokade, "Real Time Vehicle Accident Detection and Tracking Using GPS and GSM," *International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC)*, vol. 4, no. 4, pp. 232–235, Apr. 2016.



- [14]. Shailesh Bhavthankar and Prof. H.G.Sayyed, "Wireless System for Vehicle Accident Detection and Reporting using Accelerometer and GPS," 2015
- [15]. E. Krishna Priya, P. Manju, V. Mythra, and S. Umamaheswari, "IoT Based Vehicle Tracking and Accident Detection System," *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)*, vol. 5, no. 3, pp. 4424-4430, Mar. 2017.
- [16]. A. Francis and Student, "IOT BASED ACCIDENT IDENTIFICATION AND ALERTING SYSTEM," *International Journal of Pure and Applied Mathematics*, vol. 118, no. SPECIAL, pp. 547-551, Mar. 2020, Accessed: Nov. 18, 2025
- [17]. H. K. Nandish and G. Deepak, "Intelligent Navigation for Emergency Vehicles," *International Journal of Engineering and Technology (IJET)*, vol. 9, no. 2, pp. 123-128, 2017.
- [18]. S. Suganya, M. Deepa, K. Mahalakshmi, and R. Kavitha, "Vehicle Collision Detection Using GPS/GSM," *International Journal of Engineering Research (IJOER)*, vol. 4, no. 2, pp. 45-48, 2018.
- [19]. J. Ramasamy, "Intelligent Accident Detection Using IoT," *International Journal of Engineering and Advanced Technology (IJEAT)*, vol. 9, no. 1, pp. 300-304, 2019.
- [20]. Aegean Motorway S.A., *Traffic Volume Data (Raw Dataset)*, 2022.
- [21]. M. Baballe Ahmad, "Accident Detection and Alerting Systems: A Review," *Global Journal of Research in Engineering: Computer Science (GJRE-CS)*, vol. 22, no. 1, pp. 15-22, 2022.
- [22]. M. N. Mahama, A. Issah, and S. A. Sumaila, "Emergency Response Time and Trauma Survival: A Cross-Sectional Study," *BMC Emergency Medicine*, vol. 18, no. 1, pp. 1-8, 2018.
- [23]. N. Kryvinska, I. Akhmetova, and V. Khalilov, "Road Traffic Sign Detection System," *Procedia Computer Science*, vol. 130, pp. 968-975, 2018.