VANET-based traffic monitoring and incident detection system: A review

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Article Info

ABSTRACT

As a component of intelligent transport systems (ITS), vehicular ad hoc network (VANET), which is a subform of manet, has been identified. It is established on the roads based on available vehicles and supporting road infrastructure, such as base stations. An accident can be defined as any activity in the environment that may be harmful to human life or dangerous to human life. In terms of early detection, and broadcast delay. VANET has shown various problems. The available technologies for incident detection and the corresponding algorithms for processing. The present problem and challenges of incident detection in VANET technology are discussed in this paper. The paper also reviews the recently proposed methods for early incident techniques and studies them.

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1. INTRODUCTION

Nowadays, network technology is rapidly developing and widely applied. Vehicular ad hoc network (VANET) is a technology that uses cars as mobile nodes in mobile ad-hoc network (MANET) [1]. VANET converts all participating cars into a router or wireless node, allowing cars 100 to 300 meters away to connect to an extensive network. Because cars are out of the signal range and out of network, other cars can connect and connect vehicles to create a mobile internetwork as shown in Figure 1. VANET is a sophisticated technology that integrates ad hoc networks, wireless LANs, mobile technology, and sensor networks to provide advanced intelligent communications between vehicles, roadside sensors, and infrastructure [2]. VANETs are self-organizing and decentralized systems. VANET enables dedicated short-range communication (DSRC) of vehicles in the 5.9 GHz band through the IEEE 802.11 p standard. Moreover, VANET has a different scenario of communications such as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications for near and remote environments. Recently, VANET has been widely used in intelligent transportation systems (ITS) applications. Therefore, VANET is a technology that enables the integration of a single framework for conventional ITS applications [3].

The basic idea of the ITS environment is to use VANET technology to communicate vehicles to each other and communicate the infrastructure of the roadside unit to share information through the network. In safety applications and user applications, ITS applications can be divided. The number of traffic accidents will be significantly decreased, with the consequence that 60% of incidents could be prevented if the driver

were warned within 0.5 seconds of the collision. Throughout the meantime, safety applications may be used to alert drivers that the path to the next is too close. According to the US department of transportation, 45% of all registered cars and 21% of road accidents accounted for accidents at intersections in 2003 [4]. VANET can control the rate of data dissemination, which facilitates the transmission of only relevant data (for example, the traffic status of nearby roads) to each vehicle and send data to the traffic monitoring centre (TMC) [5]. Since traffic data can be distributed by multiple hops broadcasting, remote managers are likely to receive traffic data well in advance. This allows the driver to respond to the traffic information they receive in traffic monitoring [6]. Different scenarios will happen and affect the flow of data to TMC, such as wither conditions, accidents, and rush hours. These incidents will impact traffic flow and influence system performance. Hence, a new incident technique is required to be built in such a system [7]. Collecting data and detect incidents in ITS can be done by different techniques that we will discuss in the next section. An early warning performs frequent surveys when road accidents occur and produce alerts providing concise information about the type of accident designation. A method of accident prediction attempts to identify an unexpected event and its location as quickly as reliably as possible automatically [8]. However, identifying non-blocking collisions and incidents under light load is still a challenge as a difference from standard patterns of traffic may be negligible. Therefore, the limitations are that most of these algorithms do not know exactly when or what occurred [9]. We organized this paper as follow: Section 2, present all issue and challenges that implemented in incident detection and showing the points of the strength and weakness to all of them. In section 3, we will explain the recent advancement in the early incident detection system and summary of existing related work done in the past with the conclusion of this paper.
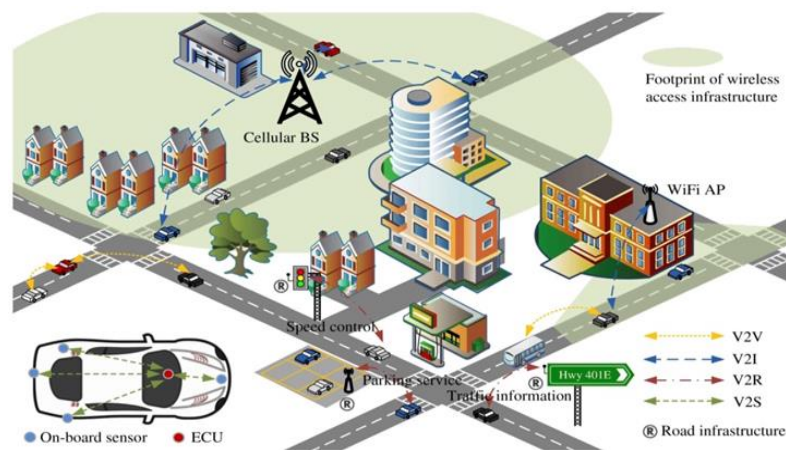

Figure 1. VANET model [10]

2.   ISSUE AND CHALLENGES IN INCIDENT DETECTION

Road incidents can be made up of many factors; some are (somehow) predictable, such as road construction, rush hour, and others are unpredictable, such as accidents, weather conditions, human behavior, and other unusual or special events affecting roadways. Without having any prior information to the drivers, road accidents, traffic congestion, and other road incidents are the most serious possible problem. As a result, the more serious the incident, the longer it will take to rectify it once the cause has been eliminated or repaired. During an incident, normal road capacity is limited, and there are often queues and delays, like in case of traffic congestions. Incidents are primarily responsible for delays and have far-reaching consequences for safety, congestion, pollution, and travel costs [11]. Earlier research has shown that incidents are one of the main causes of lost time and the increase in avoidable costs for transportation networks [12].

− The irrelevancy of incident information: Only relevant information should be provided to drivers. Independent and unnecessary information should be filtered out. This includes using accurate information dissemination. In many cases, irrelevant information transmitted by encircled vehicles or the detector node has a significant impact on traffic management. There have been cases where false alarms have been activated, and the same information has been transmitted to every node in the vehicle, which changes the direction of the traffic and obstructs the unnecessary traffic at the roadside, which complicates the ITS system. Therefore, the information to be transmitted to vehicles is an important aspect of the detection of VANET-based incidents in ITS.

− Real-time inaccessibility of information: Traffic information must be accessible in real-time. In other words, the necessary traffic information must be available to high-speed drivers. It is often the case that information transmitted by a sensor or vehicle node arrives late at other nodes. In many cases, when an emergency alert is required to prevent fatal accidents, it is transmitted late and causes an undesired accident. Therefore, access to real-time information is critical in VANET-based ITS.

Detecting and managing incidents offers better traffic monitoring. Many forms of traffic monitoring can detect an incident. The current techniques of the incident detection such as inductive loop detectors, video detection system, microwave radar sensors, automatic vehicle identification, automatic vehicle location, and wireless location technology. Table 1 present the points of strength and weakness for techniques implemented in incident detection.

Table 1. Simulation parameters for the baseline

Technique	Strength	Limitation	Characteristics
Inductive loop detectors	Data for traffic with volume, occupancy.	Maintenance, Installation, and replacement of ILDs.	Intrusive, comprising a wire coiled.
Video detection system	A single controller a combination of cameras.	Some periodic maintenance.	Non-intrusive, Software for image and camera processing.
Microwave radar sensors	Measure speed directly.	Accuracy is not good.	Non-intrusive
Automatic vehicle identification	Provide effective vehicles with data collection.	Include important infrastructure on the roads.	Non-intrusive
Automatic vehicle location	Few fixed infrastructure components are necessary.	Sample size limitations.	Relies on a global positioning system (GPS) data.
Wireless location Technology	Some vehicle owners include cell phones.	Produce reliable speed and travel time measurements.	The use of cell phones is mainly based on vehicles.

3. RECENT ADVANCEMENT IN EARLY INCIDENT DETECTION SYSTEM

In the past, many attempts have been made to invent an early incident detection system that can detect errors in intelligent transport systems as quickly as possible, to provide people with accurate primary information about alert data, and possible response times to resistance. The measures adopted to develop these systems took into account; i) the information on the accident is irrelevant drivers should only be given the applicable information. Non-relevant and redundant information should be provided. This includes the dissemination of accurate information, ii) the inaccessibility of information in real-time traffic information must be immediately accessible. In other words, basic traffic information should be accessible to drivers at high speed and iii) No timely information available Road accident information should be made available to drivers as soon as possible so that they have sufficient time to act (for example, to make a decision ahead or at the beginning). However, the implementation of the existing system could hardly produce these desirable properties. These features can save time in obtaining information on expected road accidents alongside end-user fuel. The following section discusses different research studies to develop an early incident detection system. Baiocchi et al. [5] have developed a traffic flow estimation method with GPS data and promising performance. Hojati et al. [13] have provided a model to estimate the time interval between accidents and clean-up based on road and infrastructure differences. Even IT technology has been included in traffic, incident detection, and more. The neural networks [14], supporting vector machines [15] or hidden Markov models [16] are used in these studies. In a study, Lee et al. [17] evaluated the quality of exploited data collected mostly through various roadside sensors. They pointed out that reliable and error-free data was difficult to obtain. He suggested the use of Microwave Sensors (RTSS) to obtain more reliable traffic data for traffic management systems and provided several examples in Ontario. He also introduced methods for identifying these mistakes and evaluating such models with real data. Masters et al. [18] analyzed the integrated Toronto COMPASS traffic accident detection system based on distance, road use, and speed parameters to detect data anomalies.

Feng et al. [19] calculated the corresponding data using the Bayes model to calculate the average travel time. Pascale et al. [20] focused on calculating road capacity and suggested increasing efficiency. Some studies process images and videos based on data from CCTV cameras [21]. The consequence of these systems is the ability to monitor various vehicles and their activities. Ad hoc vehicle networks are also utilized in traffic data grouping models [22], but communication and data transmission are not particularly easy in various road situations. Researchers also analyze the flow of traffic and incidents detection. The researcher [23] presented the architectural prototype e-NOTIFICATION, a new proposal aimed at improving the survival chances of passengers involved in road accidents. By using the automotive information infrastructure systems, the planned device immediately identifies warnings and assists, incident passengers. This method is built to include; i) a car immediately involved in an incident; ii) the automated transmission of

the file containing important crash details for controlling onboard devices; and, iii) a summary and automated classification, depending on information appropriate to the vehicles affected, of the losses incurred by the automobile and its occupants; The system decides on the rescue services needed to maximize support in the event of an accident, based on transmitted information and the approximate estimation of accidents.

The method aims at having the vehicle's location from the GPS receiver, transmitting the location data from SMS to the mobile number of the vehicle owner, and through GPRS to the telematic operator's server. It comprises modules; i) that require a GPS transmitter for accurate GPS GSM/GPRS satellite details; ii) The GSM/GPRS modem transfers incident position information and other information through the GSM network. The modem can be controlled using the AT commands using a microcontroller; iii) The GPS data is received, all data are analyzed, and a vehicle location is transmitted to the owner and server by the microcontroller (MCU). The scientists have suggested a safety prototype [24]. The main aim is the development of some various programs which would affect the comprehensive application and preparation of the ITS cooperatives. This also seeks to facilitate the introduction of European road cooperation programs, focusing on all issues relating to connectivity between V2V and vehicle infrastructure (V2I). The initiative aims to promote the establishment of cooperation structures on European roads. In another work carried out in [25], with a proposed automatic accident prevention system and a safety system using the integrated GSM interface, this designed system is automatic collision detection and warning system, from the GPS module and a GSM using a modem. A reliable scheme must ensure successful mechanical interaction with the entire structure of the vehicle to be secured. Throughout the case of a crash, the device can sense a rapid deceleration of the car. The accelerometer measures vehicle speed continuously, detects speeds beyond the threshold and transmits information through ADC to the microcontroller. The controller contrasts this with a collection of thresholds and delivers the pre-defined numbers automatically to the SOS message. This communication also conveys the GPS co-ordination for the vehicle, which it receives from the GPS module on a continuing process. This device can be a great benefit to find and save vehicles for accidents.

Other authors [26] have implemented a working incident prevention system and a GPS and GSM modem messaging framework. This research aims to recognize the condition of the car accident by transmitting a message through the vehicle network. The main challenge is to preserve vehicle protection at very reasonable costs. The main benefit of this check is that when the detector is activated, the GSM modem is detected immediately on the cell phone numbers stored in the EEPROM. This device reliably determines the incident location, automates the occurrence detection and communications method. The researchers from [27] proposed an emergency call notification system via the Internet of Things and the cloud. The proposed system has been Implemented using the XBee WiFi module, Xbee Shield, GPS module, Seeeduino, and the shock sensors. The basic idea is to use shock sensors to discover an accident, identify the exact location of the accident, and transmit the location coordinates via XBee WiFi to the nearest hospital via the cloud. The aim was to suggest a system that would enable the Internet and the cloud to be connected abroad. Given the above limitations, the framework represents a move forward to encourage participation in the broader Internet of Things process. Data may be transmitted over long distances utilizing the application in the cloud. This functionality may be further improved by designing the device to notify the victim's immediate family. In another work [28], a prototype system specifically designed to detect and render quick resources to victims of road accidents. The system requires that each vehicle be equipped with a control unit (CU) and an onboard unit (OBU), which indicates the location of the accident to provide the rescue operation with the necessary resources. The proposed system allows for the identification of road accidents to improve assistance to injured passengers by reducing the response time of emergency services by effectively communicating information on major accidents. The above section discusses the various related works and methods applied to the system and techniques for the early detection of incidents. The following section summarizes the researchers' current work in this area, as shown in Table 2 (see in Appendix).

4. CONCLUSION

This review paper provides an exhaustive study of existing incident detection techniques. Current techniques have been studied based on traffic monitoring and incident detection. The paper presented a relative study on roadways incident detection methods in terms of working with the pros and cons. Also, proprietary incident detection techniques have been explored to determine applications for incident detection and management. The review paper presented a comprehensive overview of field related research work. However, the literature has provided a systematic overview of related work such as traffic monitoring techniques, incident detection methods, VANET data dissemination, VANET safety, and traffic data. The study compared all available accident detection techniques and presented a comparative study of strength and weakness related to available incident detection techniques.

APPENDIX

Table 2. Summary of existing related work done in the past

Authors	Proposed scheme methodology	Issues identified	Benefits	Simulation tool
[29]	A new model for the dissemination of data based on Clustering and Probabilistic Broadcasting (CPB).	Frequent changes in topology due to increasing node mobility.	Efficient utilization of communication modes.	NS-3, SUMO
[30]	An emergency message dissemination system based on the VANET and FoG vehicle technology congestion reduction scenario.	The speed, direction, and density of the moving neighbors are not compatible.	Reduces accessibility delays and congestion.	MATLAB
[31]	A modeling language based on the actor is used and fitted with various model control engines.	Frameworks focused on simulations cannot have assured analyses.	Behavior and performance were outstanding.	Afra -modeling and verification IDE
[32]	The approach suggested is based on the concept of a supernode for timely communication. Moreover, the time barrier strategy is modified to deal with this issue to prevent the unnecessary broadcast, which can also cause the diffusion storm.	Broadcast congestion or partial broadcast.	Overhead message reduction, transmitting latency, better coverage, and packet delivery ratio.	OMNeT++, SUMO
[33]	Vehicles are dynamically clustered to tackle the storm issue and a location-based strategy aimed at reducing communication gaps is proposed that emergency messages are disseminated in time.	The frequently changed network topology contributing to network instability is caused by high mobility in-vehicle networks.	Increased transmission latency, coverage, and delivery of packets.	OMNeT++, VEINS, and SUMO
[34]	A new security-related communications protocol based on the non-redundant Communication Range (NRCR, for short), which can manage safety-relevant multi-hop messages broadcast within the non-isomeric area of communication vehicle scenario, specifically heterogeneous VANET topology.	Effective messages broadcast related to safety.	The protocol is perfect for packet receiving ratio, end-to-end delay, and overhead network.	NS-2, SUMO
[35]	A new technique to improve VANET dissemination systems to prevent further cases of emergencies and hazards by utilizing a heuristic, fast and real-time method.	Network efficiency, based on several variables including bandwidth consumption, transmission latency, and quality of service (QoS).	Improved performance of cluster duration, delivery rate, and the overhead.	NS3, VEINS, and SUMO
[36]	Across layer autonomous route recovery (CLARR) system for enhancing routing activity by decreasing the connectivity breaks for the increased multimedia dissemination of data.	High-speed vehicles often interrupted connections and loss of data packets at minimum latency.	The overall delay is highly improved efficiency.	NS3, SUMO
[37]	A reliable emergency message dissemination (REMD) framework is suggested which ensures a pre-defined reliability of messages dissemination in a variety of channel conditions while serving the delay requirements.	Recent emergency message dissemination schemes do not reach pre-defined loss channel reliability.	REMD satisfies latency requirements.	NS3, VEINS, and SUMO
[38]	A method for the dissemination of performance safety messages and detailed physical channel synchronization measurements are suggested for the connection. The organization of conflict between CFs is suggested through a score-based priority allocation mechanism for candidate forwarders (CFs).	Signal propagation is highly enhanced by obstacles at intersections in specific.	The method exceeds existing schemes for multi-hop broadcasting.	OMNeT++, VEINS, and SUMO
[39]	Also, to ensure efficient bandwidth utilization, the warning message scheme has been developed for low priority messages. During harsh weather conditions, the network provides the highest high and low priority messaging.	The processing speed of drivers as such conditions arise. Message delay dissemination.	The efficient utilization of bandwidth is less delayed.	NS-2.34
[40]	When the unexpected behavior is detected by the RSU, send an EM message to all the vehicles that are inside the RSU network. To avoid traffic collisions, an EW message will be received at the same moment.	Warning messages are timely. The message broadcast was delayed.	Low delay.	NS-2.0
[41]	The car selects the best carrier and communicates the emergency message. The transmitting of the emergency message to the RSU by the transmitter vehicle.	The probability of accidents to determine communication with messages in VANETs.	Fewer overhead message.	MATLAB, R2011b Version
[42]	The emergency message is broadcast by an RSU to the other RSUs in its network. It prevents an emergency message from duplicating. Such messages enable the driver to select a different route to prevent accidents.	Distribution of network capacity broadcast-storm issue Network congestion detection.	High throughput. End-to-end High delivery rate of the packet	NS-2.0

Table 2. Summary of existing related work done in the past *(continue)*

Authors	Proposed scheme methodology	Issues identified	Benefits	Simulation tool
[43]	The message is secured by all vehicles in the cluster to provide specific information. A traffic accident in the same cluster is identified and incident information is transmitted to the other of the cluster vehicles.	Simple Flooding.	Transmission range cluster size. Driver reaction time.	SUMO, OMNET++ VEINS, Clustering Algorithm Techniques
[44]	The drivers of vehicles have the intensity and location of the vehicle when the traffic congestion has been detected. The vehicle affected by the incident transmits the warning message to the RSU.	Bandwidth efficiency transmission. Traffic detection congestion. Transmission.	Efficient utilization of bandwidth Low overhead message	Net Beans IDE 7.0 Java

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