IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol.-6, Issue-12, Dec 2018 E-ISSN: 2347-2693

Review and Study of Intelligent Techniques in Emergency Vehicle Management System

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Available online at: www.ijcseonline.org

Accepted: 05/Dec/2018, Published: 31/Dec/2018

***Abstract*—** The major problem in the transportation system is the interference of the emergency vehicle service, like fire fighting units, ambulance, and so on. When an emergency vehicle arrives on the multilane roadways, it is tough for the private vehicle's driver to find out the correspondence of the emergency vehicle. Hence, there is a requirement of an intelligent traffic management system for effectively managing the emergency and the normal vehicles. This article surveys various research works in the field of emergency vehicle management. According to the existing works, an emergency vehicle management system is classified into six types, namely smart traffic control system, traffic timer synchronization, traffic forecasting, emergency vehicle recognition, route guidance and navigation for emergency vehicle, and dynamic path planning for emergency vehicle. Finally, an analysis is done based on the published years, techniques used, tools employed and metrics utilized in the emergency vehicle management techniques that are reviewed.

***Keywords*—** Transportation system, emergency vehicle management, traffic control, path planning, traffic forecasting.

I. INTRODUCTION

Transportation system is defined as a multifarious system, which includes various components, such as traffic management, environment, physical infrastructures, vehicles, and humans, which work together with each other in a complex manner. The transport system is susceptible to trouble, which stops the traffic flow or delays the traffic flow and it has the following characteristics: nonlinearity, dynamic, and uncertainty. One of the problems in transportation systems is the traffic congestion. The European countries, Japan, and United States have urbanized a technology, named Intelligent Transportation Systems (ITS), depending on information and communication system, which intends to resolve various problems in the transportation systems [19]. ITS technology resolves the problem of transportation, proffers efficiency, effectiveness, security and safety of traffic, improves the driving comfort, and supports the environmental conservation. This technology decreases the number of accidents and traffic congestion, saving thousands of lives on the highway. One of the commonly used ITS technologies is the Vehicular Ad-Hoc Network (VANET), which is well-liked to solve the problem of transportation systems. VANET integrates the road infrastructure, vehicle, and human via a wireless communication system. VANET has the ability to diminish the transportation complexities, improve traffic efficiency, and enhance the road safety. The proper utilization of VANETs increases the quality of urban travel [20] [10].

Emergency vehicles, like fire trucks, police cars, and ambulances hold flashing lights and a loud siren to notify motorists and pedestrians on the road. Most of the private vehicles have the tape player that fills up the inside of the vehicle with sound. Hence, the siren of the emergency vehicle is out of earshot to the driver of the private vehicles. Additionally, today's streets and highways contain large numbers of lanes. While an emergency vehicle travels on the multilane roadways, it is hard for the private vehicle's driver to find out the correlation of the emergency vehicle and to give up the right way to the emergency vehicle [8]. From this scenario, it is realized that the requirement of an intelligent traffic management system for effectively manage the emergency and normal vehicles. The superiority of the emergency service is decided based on the speed of the emergency vehicles arrive at the incident location. When an emergency vehicle can't move in traffic congestion then, it lately arrives at the incident location, which may be the reason for loss of property and lives. In order to increase the response times of emergency services and the transportation efficiency, smart traffic management system that depends on traffic density and priority is required [18].

There are a number of ways to enhance the performance of the transportation systems. The application of automation and intelligent control techniques to vehicles and roadside infrastructure is one of the ways to enhance the safety and traffic flow of the current transportation system. Traffic signal timer synchronization system provides the pre-emption for emergency vehicles. Here, depending on the density of vehicle on every side of a road junction, the traffic signal duration is attuned, which ensures that the traffic does not happen on one specific side of a road. Here, the timer is harmonized to make the emergency vehicle wail for a minimum time [4]. Another way to the proficient growth of road networks of regions at the national level, districts, and cities is the traffic forecasting [21]. In traffic forecasting, a computer model of traffic severity area's a transportation system is developed. Here, the traffic distribution is simulated based on the "user equilibrium model" principle, which means that the time used up on a trip is based on the traffic at various road sections and the driver selects the route based on the time to be sent [6]. In robotics, path planning is the major task, which selects the continuous and collision-free paths from the initial point to the destination point. Here, a vehicle can gather information regarding the neighboring environments to know barriers, attain self-localization, and so on. A vehicle can determine its path in both static and dynamic environments, when barriers occur. Dynamic path planning creates smooth optimized paths, which evades barriers while the initial and end points are known [16].

II. EMERGENCY VEHICLE MANAGEMENT SYSTEM

This section presents the overview of the emergency vehicle management system, as depicted in figure 1. An emergency vehicle management system is easily operable and helps people. The utilization of Vehicular Sensor Networks (VSNs) is the hopeful solutions for monitoring and managing the traffic. An emergency vehicle management system is classified into smart traffic control system, traffic timer synchronization, traffic forecasting, emergency vehicle recognition, route guidance and navigation for emergency vehicle, and dynamic path planning for emergency vehicle. Traffic control system is used to monitor of the movement of vehicles to guarantee safety and efficiency. Synchronization of traffic signals certifies a good flow of traffic and reduces pollutant emissions and gas consumption. Traffic forecasting estimates the number of people or vehicles that will utilize a transportation facility in the future. The emergency vehicle recognition system helps the driver and directs him/her in a secured pathway to avoid the interruption in the traffic. The major aim of the routing part in the navigation system is to determine the shortest or minimum path to reach the destination. The aim of path planning is to avoid unexpected obstacles along the path to reach the goal. The BDS/GPS compatible vehicular terminal installed on vehicles is used to obtain the real-time vehicle information in emergency vehicle management system. Then, that information is uploaded to vehicle management information system presented on the cloud computing environment via Virtual Private Network (VPN). Every user manages their vehicle by its unique password.

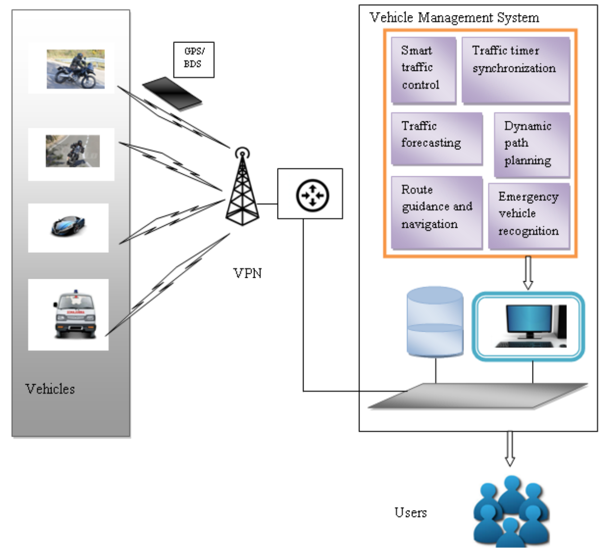

Figure 1. Model of Emergency vehicle management system

III. TECHNOLOGY AND OVERVIEW

According to the existing research works, the intelligent transport system is classified into six types, such as smart traffic control system, traffic timer synchronization, traffic forecasting, emergency vehicle recognition, route guidance and navigation for emergency vehicle, and dynamic path planning for emergency vehicle.

A. Smart Traffic Control System

This section discusses the existing research works on smart traffic control system. Veera Venkatesh and Nazneen Syed [1] have developed a smart traffic control system for emergency vehicle management. Initially, a variety of object counting and edge detection techniques were utilized to analyze the image sequences from a camera. After that, the vehicles at the junction are determined and the traffic is managed efficiently. When the emergency vehicle waits at the line of traffic, the traffic signal indication endlessly glows to green. This technique was implemented in LABVIEW. This technique needs minimum human intervention, but did not work on a multi-road junction.

Mohit Dev Srivastava *et al.* [2] have presented the primary steps needed for a smart traffic light control system depending on Programmable Logic Controller (PLC) methodology. Here, the number of vehicles in every lane and the weight of each vehicle are counted to measure the traffic density. After that, the vehicle was parked on automated parking or moved away. This method was utilized on city traffic and highways. The advantage of this method is that it controls the congestion on roads and avoids the crucial problem of traffic congestion and fatal accidents.

A smart traffic control system was developed by Yaswanth Sai Jaladanki and A Suman Kumar Reddy [3] to evade traffic congestion and to permit the emergency vehicles to go with high priority. Here, the position of the stolen vehicle was endlessly tracked. This system had utilized in numerous departments, such as safety department, health department, transportation department, police department, and so on.

B. Traffic Timer Synchronization

In this section, the existing research work on traffic timer synchronization is analyzed and discussed. In order to obtain the vehicle density, Amogh A S *et al.* [4] have utilized the image processing on OpenCV by capturing images of every road sides. When the emergency vehicle arrives, this algorithm offered the priority passage, which makes the efficient traffic synchronization, dynamic change in timer value. This method decreases the chance of traffic jams that appear due to the extensive delays in the traditional traffic light systems. Here, the drawback is that it considered pedestrians and other larger objects, such as, parked cars as vehicles.

C. Traffic Forecasting

This section analyzes the existing related works in traffic forecasting [5], [6], and [7] with their advantages. For emergency service delivery, Hafiz Abdur Rahman *et al.* [5] have established a traffic flow forecasting model. Here, the authors gathered live vehicle statistics from intervehicle networks and utilized them with a microscopic traffic simulator. This simulator helped to provide the complete illustration of urban road network. Here, the traffic data was gathered by the software and hardware tools. This method was tested on a big university campus, in which every constraint of a modern city was presented. This model was realistic and offered a valuable response to the users about the current and the future traffic circumstances. Here, the congestion detection was performed by the visual feedback of Simulation of Urban MObility (SUMO) screen output, which was unsuitable and inaccurate for automated congestion alert system.

Depending on the computer model of the transportation system for heavy traffic section, Anzhelika Dombalyan *et al.* [6] have introduced a traffic forecasting model for a road section. In traffic forecasting, the road facilities were collected from investment feasibility study to working document development. This method was forecasting traffic flows on a road section of M-4 "Don" with maximum accuracy.

Vincenzo Sciancalepore *et al.* [7] have designed the network slicing building blocks, which are accountable for (i) adaptive alteration of the forecasted load depending on the calculated deviations (ii) admission control decisions, and (iii) prediction per network slice and traffic analysis. Here, the capacity of the system increases and low Service Level Agreements (SLA) violation risk levels are occurred, resulting in high system utilization gain.

D. Emergency Vehicle Recognition

Here, the existing emergency vehicle recognition techniques are discussed. Thunugunta Swathi and B Veera Mallu [8] have introduced the Emergency Vehicle Recognition System (EVRS), which assists the vehicle to synchronize with the driver and direct him/her in a secured path while evading the traffic delay. Since toll tags become ordinary, scanning of toll tags for traffic management applications increase. The users prefer EVRS since it has drive deployment.

Bruno Fazenda *et al.* [9] established a system, which notifies the arrival of an emergency vehicle to the driver. This system was integrated with the sound reproduction system of the car and utilized the acoustic signal to warn the driver during the emergency travel. This system required further performance improvements and it was in under investigation.

E. Route Guidance and Navigation for emergency vehicles

The existing works [10-12] introduced the technique for route guidance and navigation for emergency vehicles are discussed here. Afdhal and Elizar [10] have introduced a V2I-based cooperative communication simulation to provide the route guidance and navigation for the emergency vehicle. This simulation model helps the emergency vehicle to arrive at the end point by managing the traffic information via a wireless communication networks. The method decreased the travelling time and increased the vehicle's average speed. It utilized the rare route as a substitute route to arrive at the end point although the rare route was long.

The dynamical routing guidance and the dispatching optimization methods for emergency vehicles were introduced by Bowen Gong *et al.* [11], which worked on disaster conditions and decreased the emergency response time, evaded the potential corrosion. The results of the simulation showed that these methods were significant for disaster conditions. The computing speed of these methods was in minimum.

Lei Zuo *et al.* [12] have established the inducing and navigation system by multi path dynamic information feedback. This method evaluated different road information sources and took the associated characteristics of dynamic path induction through the faith assessment of road conditions of real-time data sources. Here, the advantage is that it minimized the real-time traffic information error of the received data.

F. Dynamic Path planning for emergency vehicle

The path planning helps to evade the unpredicted barriers along the path in order to reach the destination. Here, the existing path planning methods [13-17] are disussed. Hend Kamal Gedawy *et al.* [13] developed a technique by combining the dynamic path planning and preemption. Here, a search algorithm, named D* Lite, was utilized for dynamic path planning, which plan and replan the paths in an efficient manner depending on the changing costs in the traffic network. This dynamic path planning worked well than the static path planning, even though the network is congested.

For dynamic environment, Chao Cheng Li *et al.* [14] presented a model based path planning algorithm. This model generated the candidate paths, evaluated the paths, and selected the suitable paths depending on the real-time environment. Then, the chosen paths were tracked directly till the emergency vehicle occurred. This model is suitable for complex multi-obstacle environment.

For an unmanned aerial vehicle, Victor Singh and Karen E. Willcoxy [15] have introduced the path planning method, which utilized the dynamic data-driven flight capability estimation. Based on the annotations received, the vehicle changes its path in a dynamic manner. Hence, the mission success and survival was achieved at a high probability.

A dynamic path planning algorithm for autonomous vehicles in cluttered environments was introduced by Jiefei Wang *et al.* [16]. This algorithm depends on the D* Lite algorithm, a smoothing technique, and local optimization. This algorithm determined the smoothest and shortest path from barriers.

Jiandong Zhao *et al.* [17] developed a two-stage model of dynamic path planning for emergency vehicles. Here, the objective is to determine the path, which requires minimum travel time and free of congestion. The two-stage shuffled frog leaping algorithm determined the optimal path in an efficient and rapid manner.

IV. RESEARCH GAPS AND ISSUES

This section presents the research gaps and issues of the existing works on the traffic congestion, which disrupts the traffic flow, is one of the major problems raised in the transportation system. One of the reasons for traffic congestion is the quick growth of vehicles. The other reasons for traffic congestion are ineffective traffic signs, road repairs, accidents, and increasing traffic density. Congestion disrupts the traffic flow, causes energy waste and time loss [10*]. In this research, the intelligent transport system is divided into six types, wherein number of research works is developed and are discussed in section 2. The drawbacks of the those works reviewed are described as follows,

The drawbacks of the existing smart traffic control system are described as follows: A traffic control system developed in [1] did not work on a multi-road junction. In [3], the prototype was designed by RFID scanner, which did not work for a longer range. The drawback of the traffic timer synchronization method proposed in [4] is that it considers pedestrians and other larger objects such as, parked cars as vehicles. The existing traffic forecasting methods [5, 7] has some drawbacks. SUMO road traffic simulation package utilized in [5] was inappropriate for automated congestion alert system. The time complexity of the forecasting system introduced in [7] is high. The emergency vehicle recognition system introduced in [9] attained minimum performance. The existing route guidance and navigation methods have several challenges, like the computing speed of the method in [11] was not considerable. Similarly, the existing path planning method [15] was not suitable for higher-fidelity damage models, various sensor types, wind conditions, and outsized and complicated environments.

V. STUDY ANALYSIS

This section presents the analysis of the literature works based on the published year, techniques utilized, tools, and metrics. Table 1 shows the analysis results of the existing research works on emergency vehicle management system. From the analysis based on the published years, among 17 research works, five papers are published in 2017, three papers are published in 2016, 2015, and 2009, two papers are published in 2012, and one paper is published in 2013. The techniques utilized in the research works are classified into three types, namely system, data, and network based techniques. In the system based techniques, the emergency vehicle recognition is performed in the system itself. In data based techniques, the emergency vehicle recognition is performed based on the traffic information, while in the network based system, the emergency vehicle recognition is performed based on the network infrastructure. The simulation tools utilized in the existing research works are LABVIEW, FDA Tool, SUMO, MATLAB, JASPER, ARCGIS, VISSIM, and AscTec pelican quadrotor. The metrics used for analysing the performance of the exiting methods are accuracy, system capacity utilization, time, distance, and speed.

Table 1. Result Analysis of the existing research works

Author	Year	Technique			Tools	Metrics
		System	Data	Network		
Veera Venkatesh and Nazneen Syed [1]	2015	✓	-	-	LABVIEW	-
Mohit Dev Srivastava *et al.* [2]	2012	✓	-	-	-	-
Yaswanth Sai Jaladanki and A Suman Kumar Reddy [3]	2016	✓	-	-	-	-

Amogh A S *et al.* [4]	2016	✓	-	-	FDA Tool	-
Hafiz Abdur Rahman *et al.* [5]	2012	-	✓	-	SUMO	-
Anzhelika Dombalyan *et al.* [6]	2017	-	✓	-	-	accuracy
Vincenzo Sciancalepore *et al.* [7]	2017	-	-	✓	MATLAB	System Capacity Utilization
Thunugunta Swathi and B Veera Mallu [8]	2013	-	✓		JASPER	-
Bruno Fazenda *et al.* [9]	2009	-	-	✓	-	-
Afdhal and Elizar [10]	2015	-	-	✓	-	time
Bowen Gong *et al.* [11]	2009	-	-	✓	ARCGIS	time
Lei Zuo *et al.* [12]	2017	-	-	✓	ARCGIS	-
Hend Kamal Gedawy *et al.* [13]	2009	-	✓	-	VISSIM	time
Chao cheng Li *et al.* [14]	2015	-	✓	-	-	distance
Victor Singh and Karen E. Willcoxy [15]	2017	-	✓	-	-	-
Jiefei Wang *et al.* [16]	2016	-	✓	-	AscTec pelican quadrotor	distance
Jiandong Zhao *et al.* [17]	2017	-	✓	-	MATLAB	speed

VI. CONCLUSION

The growth of number of vehicles on roadways is the major reason for traffic congestion on the road, which interrupts the emergency services. Hence, an emergency vehicle management system plays the major role in the transportation system. In traffic management, a traffic light plays a crucial role. Numbers of research works have been introduced for emergency vehicle management system. This article surveys the various research works in emergency vehicle management and analyzes the advantages and disadvantages of those methods. Based on the existing works available in the literature, an emergency vehicle management system is classified into six types, such as smart traffic control system, traffic timer synchronization, traffic forecasting, emergency vehicle recognition, route guidance and navigation for emergency vehicle, and dynamic path planning for emergency vehicle. Finally, an analysis is done based on the published years, techniques used, tools, and metrics employed of the considered emergency vehicle management techniques.

REFERENCES

[1] V. Venkatesh and N. Syed, "Smart Traffic Control System for Emergency Vehicle Clearance," International Journal of Innovative Research in Computer and Communication Engineering, vol. 3, no.8, pp. 7242-7246, 2015.

[2] M.D. Srivastava, Prerna, S. Sachin, S. Sharma, and U. Tyagi, "Smart Traffic Control System Using PLC and SCADA," International Journal of Innovative Research in Science, Engineering and Technology, vol. 1, no. 2, pp. 169-172, 2012.

[3] Y.S. Jaladanki and A.S.K. Reddy, "Smart Traffic Control System for Prevention and Control of Blockade, Emergency Vehicle Clearance and Stolen Vehicle Identification," International Journal of Innovative Technology and Research, vol.4, no.4, pp. 3253 – 3256, 2016.

[4] A.S. Amogh, S. Pujari. S.N. Gowda, and V.M. Nyamati, "Traffic Timer Synchronization based onCongestion," In Proceedings of the International Conference on Computational Systems and Information Systems for Sustainable Solutions, pp. 255-260, 2016.

[5] H.A. Rahman, J.R. Martí, and K.D. Srivastava, "Road Traffic Forecasting through Simulation and Live GPS-feed from Intervehicle Networks," In Proceedings of the IEEE Conference on Global Humanitarian Technology, pp. 36-40, 2012.

[6] A. Dombalyan, V. Kocherga, E. Semchugova, and N. Negrov, "Traffic Forecasting Model for a Road Section," In Proccedings of the 12th International Conference on Organization and Traffic Safety Management in large cities,Petersburg, Russia, pp. 159-165, 2017.

[7] V. Sciancalepore, K. Samdanis, X. Costa-Perez, D. Bega, M. Gramaglia, and A. Banchs, "Mobile Traffic Forecasting for Maximizing 5G Network Slicing Resource Utilization," In Proceedings of the IEEE Conference on Computer Communications, 2017.

[8] T. Swathi and B.V. Mallu, "Emergency Vehicle Recognition System," International Journal of Engineering Trends and Technology (IJETT), vol. 4, no. 4, pp. 987-990, April 2013.

[9] B. Fazenda, H. Atmoko, F. Gu, L. Guan, and A. Ball, "Acoustic based safety emergency vehicle detection for intelligent transport systems," In Proceedings of the conference on ICCAS-SICE, Fukuoka, Japan, 2009.

[10] Afdhal and Elizar, "Enhanced Route Guidance and Navigation for Emergency Vehicle Using V2I-Based Cooperative Communication," In Proceedings of the International Electronics Symposium, pp. 145-150, 2015.

[11] B. Gong, Z. Yang, and C. Lin, "Dispatching Optimization and Routing Guidance for Emergency Vehicles in Disaster," In Proceedings of the IEEE International Conference on Automation and Logistics, Shenyang, China, pp. 1121-1126, August 2009.

[12] L. Zuo, N. Zhang, Y. He, and T. Zhou, "Research on Dynamic Route Guidance and Navigation System Based on Multi Information Feedback," In Proceedings of the International Conference on Sensing, Diagnostics, Prognostics, and Control, pp. 421- 424, 2017.

[13] H.K. Gedawy, M.B. Dias, and K. Harras, "Dynamic Path Planning and Traffic Light Coordination for Emergency Vehicle Routing," 2009.

[14] C.C. Li, I. Wang, X. Wang, and Y. Zhang, "A Model based Path Planning Algorithm for Self-driving Cars in Dynamic Environment," In Proceedings of the Chinese Automation Congress (CAC), Wuhan, China, 2015.

[15] V. Singh and K.E. Willcoxy, "Methodology for Path Planning with Dynamic Data-Driven Flight Capability Estimation," AIAA Journal, vol. 55, no. 8, pp. 2727-2738, 2017.
[16] J. Wang, M. Garratt, and S. Anavatti, "Dynamic Path Planning Algorithm for Autonomous Vehicles in Cluttered Environments," In Proceedings of IEEE International Conference on Mechatronics and Automation, Harbin, China, 2016.
[17] J. Zhao, Y. Guo, and X. Duan, "Dynamic Path Planning of Emergency Vehicles Based on Travel Time Prediction," Journal of Advanced Transportation, pp. 1-14, 2017.
[18] K. Nellore and G.P. Hancke, "Traffic Management for Emergency Vehicle Priority based on Visual Sensing," Sensors, vol. 10, no. 11, pp. 1-22, 2016.
[19] Bringing-v2i-and-v2v-communications-to-workzone-safety, available at: http://www.itsinternational.com/sections/nafta/features/bringing-v2iand- v2v-communications-to-workzone-safety, accessed February 2015.
[20] H. Hartenstein, K.P. Laberteaux, "A tutorial survey on vehicular ad hocnetworks," IEEE Communications Magazine, vol.46, no.6, pp.164-171, June 2008.
[21] N.A. Naumova, V.V. Zyryanov, “A method of computing the traffic flow distribution density in the network with new flow-forming objects being put into operation,” Journal of Theoretical and Applied Information Technology, vol. 78, no. 1, pp. 76–83, 2015.