Pakistan Journal of Engineering Technology and Science (PJETS)
Volume 12. Issue.02, PP.116-124, December 2024
https://doi.org/10.22555/pjets.v12I2.980
E-ISSN 2224-2333
P-ISSN 2222-9930

Driver Behavior Detection and Automatic Brake Assistance for Intelligent Transportation Systems

Hira Beenish [1*]***, Tariq Javid*** [2]***, Muhammad Fahad*** [3*]***, and Akram Hussain*** [4]
[1, 3] *College of Computing and Information Science, Karachi Insitute of Economics and Technology, Karachi*
[2] *Faculty of Engineering Sciences & Technology, Hamdard University, Karachi*
[4] *Department of Computer Science and Engineering Shanghai Jiao Tong University, Shanghai, China*

*Corresponding Author: hira@kiet.edu.pk

Abstract:

Intelligent transportation systems are a cutting-edge research topic that continues to capture the interest of industry, academia, and governments. Car accidents remain one of the most serious traffic hazards, regardless of the challenges given by the vehicular revolution and the increase in the ownership of vehicles. Human error and delayed braking are the primary causes of accidents. This paper provides state-of-the-art architecture, applications, emerging radio access technologies, standardization, and resource requirements to reduce traffic congestion. The suggested model applies the brakes and generates an alert to slow down the car if there is an impending collision. Using a particular communication protocol, this paper highlights the communication between vehicles and road infrastructure. The proposed model made vehicular communication possible and has been extremely beneficial to the automotive industry. Road safety and traffic congestion will be enhanced by the model presented in this paper. By delivering signals and messages that indicate the impending outcomes, an integrated wireless network system allows real-time communication between vehicles and infrastructure in addition to facilitating vehicle-to-vehicle communication.

Keywords: *Autonomous vehicles, intelligent transportation system, vehicular communication, Vehicle to vehicle communication, vehicle-to-infrastructure communication*

I. INTRODUCTION

Driver warning systems alert the driver of impending collisions or other dangerous situations. These systems provide an auditory or visual warning to the driver and use a variety of sensors, such as cameras and radar, to identify potential hazards. Some systems may also provide additional assistance, such as steering or brake support, to help the driver get out of danger. Automatic brake systems, often known as automated emergency braking (AEB) systems, are designed to apply the brakes in an emergency automatically. These systems use sensors to identify potential crashes and apply the brakes if the driver does not take action to avoid the hazard. These systems also use sensors to detect potential collisions and uncomfortable situations if the driver does not take action to avoid the hazard. Automatic brake systems can be activated in a variety of situations, such as when the vehicle is approaching a stationary object too quickly or when another vehicle is detected in the driver's blind spot. These systems are intended to increase vehicle safety and reduce traffic accidents. While several automakers now offer them as standard or optional equipment on their models, these systems are becoming more prevalent in new cars. The objectives of automatic brake systems and driver warning systems are to increase vehicle safety and lower the number of traffic accidents. Recent models of cars are starting to be equipped with these systems more frequently; numerous car companies provide them as optional or standard features. As traffic congestion increases, there is an increasing emphasis on vehicle communication to address connected problems. This will enhance road safety, decrease accidents, and improve traffic efficiency. Vehicle communication systems, in general, are computer networks that specify every aspect of vehicle communication, including how cars interact with one another and the protocols they use to prevent various types of traffic and safety issues. In this context, vehicular communication relies significantly on the OSI architecture's physical and network layers. The physical layer provides the expansion and connectivity required for effective vehicle communication to infrastructure. To achieve this, a vehicle channel is used, and its features, models, and other characteristics distinguish it from other wireless systems. The authors introduced different approaches to evaluating the time-varying channel to control high-versatility channels to complete communication across the vehicular infrastructure and OBUs. Therefore, the authors presented the usage of physical layer assistants in the detection of issues and improve the functionality of the vehicle communication system [1]. The network layer is also significant for vehicular communication because it enables active and dependable connections between cars by facilitating information transfer from vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). It can be challenging to provide a reliable and secure vehicle platform to meet multiple objectives, like increased reliability and reduced latency, as vehicle communication supports a wide range of applications in the smart transportation and safety environment. Therefore, a new driving style known as autonomous driving has been developed within the vehicles that can utilize sensor technologies, wireless connections, processing capacity, and intelligent control to tackle the communication problem from the perspective of the network layer [2].

A. Vanets In Vehicular Communication

Vehicular ad hoc networks are used to handle Communication between moving vehicles. The phrase for direct communication between two cars is "vehicle-to-vehicle" (V2V) communication. Vehicle-to-infrastructure (V2I) communication refers to direct communication between a vehicle and an infrastructure. Onboard units and roadside units are the different types of components used in vanets. While RSUs are based on the infrastructure in which radio equipment is installed, these onboard units (OBU) are deployed in cars as well. Through dedicated short-range communication (DSRC), the two vehicles and vehicles to infrastructure can communicate with one another [3]. The authors discussed the perspective of VANETs in light of connection issues with the vehicles paradigm. The authors provided a model for ITS implementation by using a dual-band or full duplex. As the number of vehicles on the road grows, the world will face challenges in these circumstances, such as vehicle ad-hoc networks (VANETs), intelligent transportation systems, and cars traveling at very high speeds [4]. RSUs and vehicles are communicated through the 5th generation. The authors of the paper [22] presented a review of all 5G technologies for wireless communication with broad applications in smart industries, smart cities, and health.

B. Intelligent Transportation Systems

Intelligent transportation systems (ITS) have a significant impact on daily life. Since they have relied on several applications for reliable and efficient traffic safety. For the deployment of IT in vehicular communication, the authors illustrate a dual-band for full-duplex since vehicular communication enables direct information sharing between cars through V2V and V2I. The onboard transceiver of a vehicle communicates, works with infrastructure, and transmits data to a roadside unit (RSU) for real-time communication[5]. These applications also incorporate emergency alerts, traffic updates, and road uncertainty. They also present alerts for collisions at intersections, head-on collisions, and rear-end collisions, which is another way to disseminate information. Driving will be less dangerous with these techniques. The authors also worked on the V2I front and a co-design strategy that isolates the high frequency between the receiving and transmitting channels (RX and TX channels), as well as improvements to dual-band duplex antennas with frequency selection and chancel isolation [5]. ITS has different modes of transfer, which are explicitly transfer methods through ITS specifically designed for vehicular communications. These protocols included Bluetooth, IEEE Zig Bee, LTE-V2V, and IEEE 802.11p. Each of these protocols was created to speed up connections and improve street security and road safety as well. These are also discussed in Tables 1-2 and Table 4 specifically for protocols. Different frameworks, including anti-collision sensors, driver notification systems, and autonomous driving, have been installed in cars for vehicular communication [6]. Two technologies were presented by the authors, mainly by the intelligent transportation system using communication technology, smaller-scale circuits, and sensors. There are vehicular ad hoc networks (VANETs) in which there is no packet delay, and another is feedback-based eco steering (FB-ECO), which is intended to reduce fuel consumption by directing the driver along the most environmentally friendly routes but has the drawback of a longer packet delay and a higher packet drop rate, which results in the loss of all the updating packets [7].

C. 3rd Generation Partnership Project

3GPP is a combination of a group of standards of telecommunication to create third-generation (3G) mobile networks. It works on WIFI, radio access, security, and quality of service. A vehicle is a strong moving node that communicates and exchanges information by using different services like V2V, V2I, V2P, and V2N V2X. It also reviews the current changes and upgrades of 3GPP correspondence frameworks for vehicular communication and different interfaces that are designed to help V2X administrations. The authors discuss the upgradation for long-term evolution (LTE) to address the portion of the execution of V2V administrations they portrayed for both side link transport and cell transport [8]. Third Generation Partnership Project (3GPP) also presented an open-source simulation model that compasses on the application layer. Several models worked step by step. During the past two years, the fully open-source C-V2X, mode 4 execution, has made a good impact on the vehicle contact network [9].

D. 5th Generation

In the age of digital communication, vehicle communication is essential since it promises to give us safe and secure latency and intelligent connectivity. Important 5G components, its architecture, and features that are helpful for vehicular communication are highlighted in [10]. Wireless technologies like LTE, higher-speed packet connectivity, the Worldwide Smart-Phones Communications Network, Wi-Fi, and others are used to build a communication platform that can provide services to technologies that use proximity on knowledge, network splitting techniques, software interpreting networks (SDNs), mobile computing edges (MCE), and radio frequency communication [10].

E. Vehicle Communication Network & Vehicle Platooning

A vehicle communication network consists of devices that connect the vehicles and other transceivers with different wireless communication modules to access the information. The authors presented the concept of automated driving, in which vehicles could be able to drive without human involvement. It should be capable of sensing road situations with the help of cameras, car sensors, and transceivers to make decisions based on the road situations. VCNs communicate with devices that enable interaction and cooperation on the road. But there are some restrictions in this driving, like sensing range, datasets for training, processing capabilities, and so on. To solve these issues, a case study is performed on automated intersections, which proves that communication-based control systems can improve transport efficiency and intersection passing delay [11]. Vehicle platooning is a group of vehicles that can move together safely in a series at high speed; it requires some mechanical coupling like Bluetooth, GPS, and drive-by-wire steering to take control of the cars. Vehicle platooning depends on the vehicle-to-vehicle interaction, as well as the stability and coordination of the device. To do this, 5G-V2X and 802.11p concept hardware is used for connectivity, and packets between vehicles are shared via user datagram, protocol (UDP), and on-board vehicle sensors (camera, radar, etc.), and V2V contact is generated to ensure traffic movement and less fuel consumption. [12].The authors discussed multiple techniques that are incorporated with these types of technologies [22].

F. Security Challenges in Vehicular Communication

As the growing use of electronic technology has changed the perception of transport in the last few years, modern cars have become complex and sophisticated systems as those provide a large range of services to communicate the interconnected different EU and groups to form intra and intervehicle networks. These EUs are interconnected with each other using different communication buses. The cars can directly link to (the internet, android phones etc.) and can interact through gateways with the electrical charging system, monitoring, keyless access etc. [13]. Enabling V2V communication in distant networks is the most difficult challenge in V2V communication. A multidimensional moving-target defence (MTD)–inspired design that is safe against attackers has been created to address these. Numerous V2V applications are unconfined while keeping a safe distance from any kind of traffic obstructions. However, certain V2V applications are ineffective in providing reliable vehicle-to-vehicle communication since attackers may readily decode the data and there is no dependability or security [14]. The vehicular network requires high accuracy for V2V contact for message protection in-vehicle communications. To analyze the process quantitatively, the approach combined for all of these types of communication has been examined in many articles. To meet these requirements, however, many systems need security, high dependability, and low latency. Two models, particularly 3GPP, present the concept of V2X communication by utilizing the IEEE 802.11p and C-V2X protocols, which have been studied in [15]. When rigorous reliability was required, 802.11p had issues. However, C-V2X was very successful in providing all features, including dependability, reliability, and fast data rate communication [15]. The Internet of Vehicles (IoV) aids in the understanding of smart transportation systems by allowing vehicles equipped with processing nodes, sensors, and software to communicate with one another. Various networks utilized in the maintenance of smart public transportation systems are indispensable in terms of ensuring reliable operation [24]. A traffic stream model is also used to determine the vehicle's location, mapping, and speed of cars. It worked on approach-based cars that are traveling on a two-lane highway. A mathematical closed-form equation was also presented using the proposed model for the proposed scheme of actual or fake data alternation of channel efficiency and probability [14].

II. LITERATURE REVIEW

According to the World Health Organization (WHO), vehicle accidents kill 1.3 million people each year. The biggest risk factors in road accidents include speeding, driving under the influence of alcohol, distracted driving, hazardous vehicles, and unsafe infrastructure. Better driver assistance and the shift to autonomous driving can both benefit significantly from recognizing driver intentions and informing the driver to predict the expected driving actions, enabling timing improvements, the ability to start or stop an interaction, and seamless aided driving. Numerous articles emphasize various V2V communication techniques and incident traffic management systems that work on preventive approaches for vehicles, ambulances, etc. To overcome traffic congestion, they have built a highway intersection model that monitors vehicle mobility and illustrates vehicle communication (V2V, V2I). Furthermore, using VANETS presents a number of challenges due to its highly distinctive architecture and required adaptability, making MANET protocols inappropriate for VANET [3]. The most efficient method for IT'S, MANET, is a subtype of the vehicular ad-hoc network since it enables wireless communication between passing vehicles in accordance with IEEE standard 802.11p. The vanet is used to regulate traffic and arrange routes from point A to point B as it changes the vehicle data from the source to the destination [4]. The Intelligent Transportation Systems (ITS) provides an increase in the health, performance, comfort, and help of the transport management system [5, 6]. The authors worked with the coordination of IEEE 802.11p protocols related to the VANET and Ethernet cellular networks using vehicle gateways to carry out various vehicle correspondence. IEEE 802.11p is used for V2V connectivity and LTE-based protocols for V2I interactions [6].

All of the information about the communication technologies that are used for vehicular communication, including their scope and the numerous properties and parameters they possess, has been presented in Table 1.

Table 1: Wireless Technologies and its range used in vehicular communication

References	Technology	Range	Attribute
[10]	Mm Wave	10m	Higher speeds, Lower latency
[12]	Bluetooth	10-30m	Low power, good communication
[2]	WIFI	76-122m	High data transfer rate
[3]	DSRC	1000m	High reliability
[9]	GPRS	56-114 Kbit/sec	Moderate data transfer speed
[8]	LTE	100Mb/s	Large coverage and instant data transfer speed

Table 2 describes each of the IEEE standards that are utilized in vehicular communication as well as the characteristics that they possess. The parameters that have been presented in research articles from various years are listed. Table 3 presents the different applications that are being used in different research articles in the literature.

Table 2: IEEE Standards Implementation Features

Reference	IEEE Standard	Features
[6]	802.15.4	Used to reduce connection times
[7]	802.11p	It introduced vehicular communication in V2V and V2I and for Wireless Access in Vehicular Environments.
[11]	802.11p	Used for resolving issues like low latency and reliable transmission in vehicular communication
[12]	802.11p	Used for communication and the packets between vehicles are exchanged through UDP also on-board vehicle sensors.

Table 3. Intelligent Transportation Systems Applications and Technologies

References	Years	ITS	LTE	3GP	VANET
[1]	2017	✓	✓	✓	✕
[3]	2017	✓	✕	✕	✓
[5]	2018	✓	✓	✓	✕
[6]	2019	✕	✕	✕	✓
[7]	2019	✕	✓	✓	✕
[9]	2019	✕	✕	✓	✓
[10]	2018	✕	✓	✓	✓
[11]	2018	✓	✕	✓	✕

III. METHODOLOGY

Driver alert systems are designed to help drivers remain alert and focused while driving. These systems typically use sensors and other technologies to monitor the driver's behavior and alert them if they show signs of drowsy or distracted driving. The purpose of this study is to evaluate how a collision warning system affects the drivers' abilities to avoid collisions and the feasibility of the system. Based on the findings from driver test data in traffic, a driver model is proposed in this research to simulate braking activities. A general model has been developed with a set of parameters to capture unique driving traits. In the presented model, the purpose of a vehicle-based device's communication is to alert the driver. Initially, the car's three sensors locate and follow objects in its surroundings. The sensor tracks the distance, computes the speeds and collision time, initiates the forward collision alert, and establishes the stopping distance when a car gets close to the leading vehicle, as shown in Figure 1. According to the driver's assessment, such devices are still incapable of taking any preventive action. The vehicles will be able to shift their route and choose alternate routes that would avoid a busy town using this information. The discussion of how to successfully integrate V2V (vehicle-to-vehicle)-based road safety control systems with collective traffic control approaches will then be a central concern. The model for automatic emergency braking is presented in Figure 2. Accessibility Analysis of the Vehicle-to-Vehicle Interaction System's Crash Prevention Process is an active safety feature that uses in-car environmental awareness sensors, such as radar and cameras, to assess the level of risk between the vehicle and the vehicles ahead of it. It helps prevent accidents by automatically putting the brakes on in critical circumstances. Different technologies are also connected to vehicular communications, like sensors and cameras. Loop and magnetic detectors, GPS tracking, and cellular connections with cell towers with mobile phone probes. The V2X, which defines a generalization, completes the previously stated V2V and V2I communication models. The last category includes data transmission from a vehicle to any entity that can impact it. Communication is possible using wireless components contained in mobile phones' cellular connections, such as Wi-Fi, Bluetooth, and Near Field Communication (NFC).

Table 4: ITS Technologies and the Information Regarding their Protocols

References	Safety Application	Communication Type	Traffic Information	Transmit Mode
[17]	Traffic signal violation warning	Vehicle-to- infrastructure	Traffic signal status and warning	Occasional
[20]	Signal of Left turn movement	Vehicle-to- infrastructure	Traffic signal status and cautioning, vehicle position, speed, head	Occasional
[20]	Signal of stop sign movement	Vehicle-to- infrastructure	The direction of the vehicle its head and speed rate	Occasional
[16]	Intersection collision warning	Vehicle-to-vehicle	Vehicles, head, speed rate, signal change position	Event-driven
[18]	Electronic indicator for Brake lights	Vehicle-to-vehicle	The direction of the vehicle its head, speed rate and declaration	Event-driven
[19]	Pre-cash sensing	Vehicle-to-vehicle	Safety sensors, seatbelts	Event-driven
[16]	Work zone warning	Vehicle-to-infrastructure	Reduce speed limit, distance to work	Occasional
[21]	Collision risk alerting	Vehicle-to-vehicle	Information from sensors attached to vehicles	Event-driven
[17]	In-vehicle sign	Vehicle-to-infrastructure	Indicate signs of traffic signal	Occasional
[20]	Blind merge alert	Vehicle-to- infrastructure	Vehicle direction, speed rate, warning	Occasional
[18]	Highway merge collaborator	Vehicle-to-vehicle	The direction of the vehicle, its head, speed rate, merge path	Occasional
[19]	Lane change alert	Vehicle-to-vehicle	It screens the point of the vehicle, speed	Occasional

IV. RESULTS AND DISCUSSION

Considering the braking system's properties, this research proposes a brake system for an automated driver warning alert system. Because the front and rear wheels of the recommended brake system are equipped with brakes, neither a pedal simulator nor a fail-safe device is required. This study aims to evaluate the effectiveness of the brake system and its implementation. Several components, including those used to demonstrate the concept of automatic brake systems, have an ultrasonic sensor implanted to detect surrounding vehicles and objects. The sensors used for V2V communication precisely evaluate the passenger status of both the vehicle and the surrounding vehicles by collecting data from the suspension to measure the roughness of the road. The weather, passenger circumstances, road roughness, and driving information are all considered while determining the ideal brake pressure strength and steering angle. This paper introduces a decision-making-based model and a reliable sensor fusion architecture for an autonomous emergency braking system. In the future, advanced fault-tolerant approaches to sensor fusion may be employed to achieve more robust and dependable detection from sensors. To improve the system's accuracy and efficiency, pro

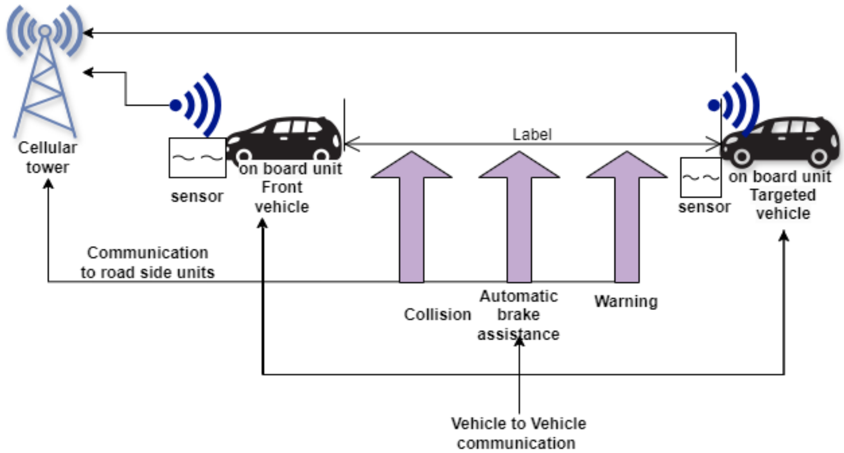

Figure 1: Proposed Communication/Action Model

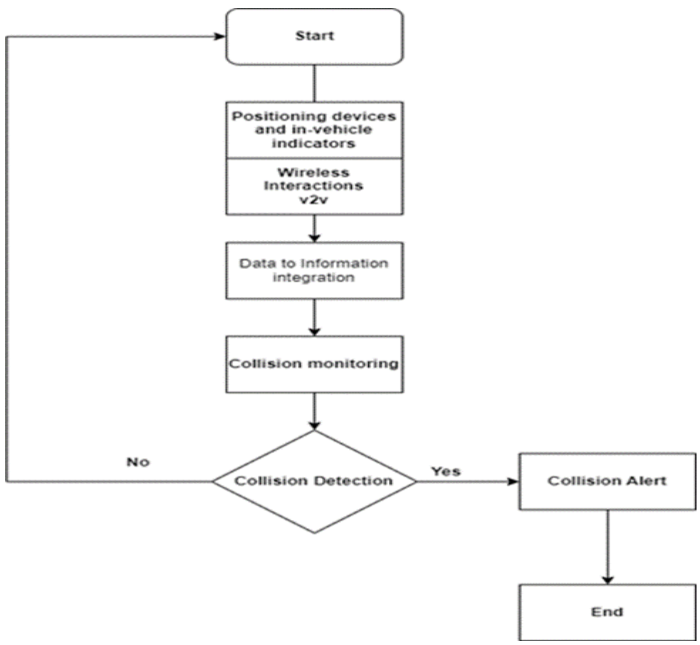

Figure 2: Proposed Model Flow Diagram

cessing delays induced by the environment may be taken into consideration. To analyze the situation of the moving target vehicle, the road and vehicles were changed to correlate with the stationary target vehicle condition. The target car moves slowly in front of the investigated vehicle. The two vehicles travel the same route on the road. The targeted car travels down the centre of the line. When the horizontal space between two cars exceeds the average of their widths, even if the distance between them is already pretty close, there is no risk of a collision since two cars that are driven somewhat differently often do not move in a straight line. According to the Markov algorithm. When the system delay time and the driver reaction time have passed, the following vehicle will begin to brake at its maximum deceleration, The following car will then begin to brake at maximum deceleration. Two cars are separated by d, with the first indicated as A and the second as B. The vehicle's speed is V, and braking is h. The Markov chain model is used in the below equation 1 to compute the collision avoidance between the two cars that are based on the distance between the two cars

$$\pi = \pi p \quad (1)$$

According to Markov chain property, it is represented and as mentioned in [24]. An automatic braking system is applied to vehicles based on the distance between the front vehicle and the targeted vehicle. As shown in equation 2, here,

V= vehicle speed

D= Distance between two vehicles

G = Friction of road and the tires

$$D = \frac{V}{F+G}. (\pi p) \quad (2)$$

Considering the Markov chain property, we utilize the distance-based braking equation in the Markov property equation as shown above.

V. CONCLUSION

Within the scope of this paper, we provided an overview of vehicular communication from a data perspective. The very effective and reliable vehicle communication technologies will provide safety and security to the roadside units while also reducing traffic congestion on the road. To develop this type of communication system, numerous vehicular routes and wireless connections are incorporated into the vehicular architecture. Furthermore, various issues related to security and reliability, specification, and architecture are discussed. To provide the most dependable communication between vehicles, there must be no packet delivery delays or dependability difficulties in V2I and V2V communication. In addition, this piece discusses several protocols that have been specifically built to meet different kinds of traffic congestion and road congestion issues given by ITS. In this paper, we examined the different technologies designed to identify vehicle locations, maps, and speeds to enable reliable communication between vehicles. Our main objective is to reduce the number of collisions that occur while also decreasing the overcrowding that follows from them. The proposed model improves the existing systems by shifting the focus away from the driver toward warning and onto vehicle communication. This allows the car to take control of the situation and regulate its status, which is a step up from the old approach of contacting drivers. In the long term, we will be able to include this model in a simulation environment to further optimize the findings.

CONFLICT OF INTEREST

There is no conflict of interest between all the authors

REFERENCES

[1] Communications: A physical layer perspective. IEEE Transactions on Vehicular Technology, 66(12), 10647-10659.

[2] Peng, H., Liang, L., Shen, X., & Li, G. Y. (2018). Vehicular communications: A network layer perspective. IEEE Transactions on Vehicular Technology, 68(2), 1064-1078.

[3] Gafencu, L. P., Scripcariu, L., & Bogdan, I. (2017, July). An overview of security aspects and solutions in VANETs. In 2017 International Symposium on Signals, Circuits and Systems (ISSCS) (pp. 1-4). IEEE.

[4] Din, I. U., Kim, B. S., Hassan, S., Guizani, M., Atiquzzaman, M., & Rodrigues, J. J. (2018). Information-centric network-based vehicular communications: Overview and research opportunities. Sensors, 18(11), 3957.

[5] Mao, C. X., Gao, S., & Wang, Y. (2018). Dual-band full-duplex Tx/Rx antennas for vehicular communications. IEEE Transactions on Vehicular Technology, 67(5), 4059-4070.

[6] Arena, F., & Pau, G. (2019). An overview of vehicular communications. Future Internet, 11(2), 27.

[7] Elbery, A., & Rakha, H. (2019). City-wide eco-routing navigation considering vehicular communication impacts. Sensors, 19(2), 290.

[8] S. Tsugawa, “Trends and issues in safe driver assistance systems,” IATSS Res., vol. 30, no. 2, pp. 6–18, 2006. [9] McCarthy, B., & O'Driscoll, A. (2019, September). OpenCV2X Mode 4: A Simulation Extension for Cellular Vehicular Communication Networks. In 2019 IEEE 24th International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (CAMAD) (pp. 1-6). IEEE.

[10] Shah, S. A. A., Ahmed, E., Imran, M., & Zeadally, S. (2018). 5G for vehicular communications. IEEE Com munications Magazine, 56(1), 111-117.

[11] Zhang, S., Chen, J., Lyu, F., Cheng, N., Shi, W., & Shen, X. (2018). Vehicular communication networks in the automated driving era. IEEE Communications Magazine, 56(9), 26-32.

[12] Jain, V., Lapoehn, S., Frankiewicz, T., Hesse, T., Gharba, M., Gangakhedkar, S. ... & Zou, Y. (2017, November). Prediction based framework for vehicle platooning using vehicular communications. In 2017 IEEE Vehicular Networking Conference (VNC) (pp. 159-166). IEEE.

[13] Bernardini, C., Asghar, M. R., & Crispo, B. (2017). Security and privacy in vehicular communications: Challenges and opportunities. Vehicular Communications, 10, 13-28.

[14] Ghourab, E. M., Samir, E., Azab, M., & Eltoweissy, M. (2019). Trustworthy vehicular communication employing multidimensional diversification for moving-target defense. Journal of Cyber Security and Mobility, 8(2), 133-164.

[15] Gu, X., Leng, B., Zhang, L., Miao, J., & Zhang, L. (2020). A Stochastic Geometry Approach to Model and Analyze Future Vehicular Communication Networks. IEEE Access, 8, 14500-14512.

[16] Papadimitratos, P., Buttyan, L., Holczer, T., Schoch, E., Freudiger, J., Raya, M & Hubaux, J. P. (2008). Secure vehicular communication systems:

design and architecture. IEEE Communications Magazine, 46(11), 100-109.

[17] Festag, A. (2015). Standards for vehicular communication—from IEEE

802.11 p to 5G. e & i Elektrotechnik und Informationstechnik, 132(7), 409- 416.

[18] Kihl, M., Bür, K., Mahanta, P., & Coelingh, E. (2012, July). 3GPP LTE downlink scheduling strategies in vehicle-to-infrastructure communications for traffic safety applications. In 2012 IEEE Symposium on Computers and Communications (ISCC) (pp. 000448-000453). IEEE.

[19] Papadimitratos, P., De La Fortelle, A., Evenssen, K., Brignolo, R., & Cosenza, S. (2009). Vehicular communication systems: Enabling technologies, applications, and future outlook on intelligent transportation. IEEE communications magazine, 47(11), 84-95.

[20] Al-Sultan, S., Al-Doori, M. M., Al-Bayatti, A. H., & Zedan, H. (2014). A comprehensive survey on vehicular ad hoc network. Journal of network and computer applications, 37, 380-392.

[21] Saito, M., Nakamura, K., Manaka, T., & Nakahara, T. (2005). U.S. Patent No. 6,972,669. Washington, DC: U.S. Patent and Trademark Office

[22] Beenish, H., & Fahad, M. (2019, January). 5G A REVIEW ON EXISTING TECHNOLOGIES. In 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET) (pp. 1-6). IEEE.

[23] Birrell, S. A., Young, M. S., Jenkins, D. P., & Stanton, N. A. (2012). Cognitive Work Analysis for safe and efficient driving. Theoretical Issues in Ergonomics Science, 13(4), 430-449.

[24] Beenish, Hira, Tariq Javid, Muhammad Fahad, Adnan Ahmed Siddiqui, Ghufran Ahmed, and Hassan Jamil Syed. "A novel Markov model-based traffic density estimation technique for intelligent transportation system." Sensors 23, no. 2 (2023): 768.