International Journal of Engineering, Management and Humanities (IJEMH)
Volume 4, Issue 5, Sep.-Oct., 2023 pp: 428-435 www.ijemh.com

Enhancing Safety, Navigation, and User Experience with AR Integration in 5G-Powered Autonomous Vehicles

Jael Hephzibah, Madhumitha S

Jael Hephzibah, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu
Madhumitha S, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu

Date of Submission: 15-10-2023 Date of Acceptance: 31-10-2023

ABSTRACT: The advent of 5G Technology exemplifies a breakthrough in the world of teleconnections and connectivity by offering faster data speeds, lower latency, and increased capacity. It's a big deal because it can connect lots of devices at once like mobile phones, smart watches, even cars and one of the pivotal of 5G communication is Proximity Service (ProSe) which provides a rapid interaction and communication within a certain locality. This paper delves into the integration of Augmented Reality (AR) technology in 5G-powered autonomous vehicles. The future with autonomous vehicles upholds the potential for safer roads, traffic free zones and improved transportation services. The mainstream problem we are addressing is how to make self-driving cars safer, easier to navigate with best user experience. We have to use 5G Technology and augmented reality (AR) for an interactive experience by improving overall driving and passenger safety. Autonomous vehicles involves various interconnected elements like vehicle-to-everything (V2X), vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-pedestrian (V2P) communication. The autonomous vehicles produce a huge extent of information in the form of indicators, radiated by sensors positioned in and around the vehicles. The evoked data is addressed by authorized executives, other transports and infrastructure in the grid for taking decisions in the right time. This would allow them to communicate among themselves. The AR works by overlaying the digital information into the physical environment by utilizing sensors, radar, GPS and cameras to gather information about the surrounding and provides data with designated display to navigate autonomously without or minimum human input. This information provides the users with navigation instructions, real-time traffic updates and possible risks in a non-intrusive manner. This combination of autonomous vehicles with AR enhances situational awareness and contributes to a safer driving experience.

KEYWORDS: 5G Technology, autonomous vehicles, augmented reality, user experience, automation.

I. INTRODUCTION

The emergence of 5G technology has pioneered new sphere of possibilities for the automotive industry , especially in the realm of autonomous vehicle advancement. Operating a vehicle with minimal or no human intervention has become possible due to emergence of cutting –edge technologies like rapid networks, distributed storage systems, fog computing and others. Autonomous vehicles, often referred as self-driving or driverless cars, operate without the need of driver input. Also the driver does not have to constantly monitor the roadway. This technology have transitioned from being a distant dream to a rapidly approaching reality. A crucial force driving this evolution in the automotive industry is the convergence of autonomous vehicles with 5G technology. Autonomous vehicles presents to be an encouraging technology due to advanced safety systems and heightened energy effectiveness. These vehicles frequently rely on camera and sensor based technologies, while advanced may not replicate the subtle awareness of human drivers, creating challenges in intricate or violate traffic scenarios. Autonomous vehicles are highly reliant on sophisticated infrastructure, including specialized road maps and designated lanes. Augmented reality is needed to have unlimited use of these elements. The technology for autonomous vehicles, especially without the presence of AR integration, often can be expensive. Autonomous vehicles are interconnected devices, exposed to cyberattacks. Without robust security measures, they may be at a risk of hacking and data breaches. Augmented Reality (AR) has risen visibility as a game-changing technology, reconfiguring our interactions with the digital and physical words. AR empower users to delve new dimensions, diversion, navigation, and problem solving. AR smoothly merges computer generated content with our real world environment, resulting in engaging and participatory experience that enhances comprehension and interaction with the surroundings. It is versatile and relevant over a broad spectrum of domains. This integration is typically executed using smartphones, smart glasses, or AR headsets, provided with cameras and sensors for acquiring the real world and presenting augmented components. It provides 3D models and simulations. AR is adopted for training, remote assistance, and maintenance by many industries. The fusion of autonomous driving systems with Augmented Reality (AR) technology is primed to transform the way we experience and engage with autonomous vehicles, presenting a myriad of benefits in terms of safety, navigation and user experience. Autonomous vehicles are quickly evolving into reality, offering the promise to reduce accidents caused by human error, traffic gridlock and deliver convenient mode of transportation. Incorporating 5G and AR into autonomous vehicles enhances these perks to a new echelon, improving the capabilities and experience. Safety, navigation and user experience are positioned for significant overhaul, deep alteration more than mere transportation, but a journey of convenience, productivity and amusement. With the ongoing expansion of 5G and the continuous advancement of AR technology, we are on the cusp of an exhilarating future, autonomous vehicle will become secure, smart and more captivating.

II. LITERATURE REVIEW

The numerous research and journal papers based on AR, autonomous vehicles and 5G technology are presented below in chronological order,

In 2014, "Intelligent Transportation Systems in Future Smart Cities", authors concentrated on Intelligent Transportation system (ITS) which focuses on transportation safety, mobility and environmental sustainability. Queue warning system communicates the location of back-of-queue (BOQ) situations to the drivers to ensure safe breaking using LiDAR. Automatic Incident Detection (AID) leverage data traffic, encompassing such as speed, occupancy to address traffic disruptions [1].

In 2015, M. Billinghurst *et al* reported on the survey outlines of Augmented Reality (AR) beginning from its inception in the 1960s to its ubiquitous availability in the 2010s.It explains clearly about the objective of seamless real-virtual integration. It examines about the basic mechanisms such as monitoring, display and input apparatus. This provides an overview of how AR fits into typology of other mechanisms and it is concluded with an overview of potential research directions for the future with an analysis of the continuing inquiries within specific domains [2].

In the year 2017, Seung-Hwa Jun *et al* conducted a comprehensive survey on the demonstrations of various cutting-edge technologies like VR/AR/MR services in PyeongChang Winter Olympics. KT was the South Korean telecommunications company called KT Corporation which was the sponsoring telecommunications operator during the 2018 Olympics. Their demonstrations include a 5G autonomous driving bus, and drone delivery initially tested in February 2016 and later upgraded in December [3].

In the year 2018, Pengyuan Zhou *et al* concentrate on the Augmented Reality Applications in Vehicle to Edge Networks (ARVE) that comprises of environment, vehicles and edge servers in which the environment encompasses of road network, roadside buildings and pedestrians. In which the ARVE has two tiers of servers : Tier1 Edge Server(T1 ES) located with the base stations and Tier2 Edge Servers (T2 ES) is positioned near aggregation points. These servers collaborate to ensure effective communication with vehicles and roadside units (RSUs) using a close-by radio network. This arrangement improves operations such as enhancing the smooth movement of traffic by sending cruise control messages [4].

In the year 2019, Khazraeian, S and Hadi, M. focus on the case studies on connected vehicle including queue warning systems and automatic incident detection systems. Queue warning systems alert drivers about the end of traffic congestion promoting self-braking practices. Simultaneously, automatic incident detection system leverage traffic data such as speed, volume, and utilization to autonomously identify traffic incidents [5].

In 2019, P.Zhou *et al* enhanced and discussed a novel approach to tackle the communication infrastructure challenges in automotive communication systems with focus on augmented reality systems and autonomous vehicles. This paper introduces approach to address latency and intricacy. Latency has been reduced by bringing computation closer to the edge of the network. This signifies consequences for applications that demand immediate responsiveness in the context of vehicles [6].

In the year 2020, Hyunbum Kim *et al* discusses the confluences of 5G technology and AI-driven applications in the circumstance of security. This is done with a focus on affecting computing systems. This paper provides profound revelations into the incorporation of 5G technologies and AI in smart cities and autonomous systems. Concept of virtual emotion system has been successfully introduced. The significance of security threats have also been highlighted [7].

In 2020, Chandupatla *et al* examines the application of augmented reality in the automotive industry, precisely for vehicle automation systems. This paper addresses a significant concern to the incorporation of augmented reality in driverless vehicles. It also describes the capability to enhance driver assistance. Highlights have been done on the gap regarding user adoption of AR technology and

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 4, Issue 5, Sep.-Oct., 2023 pp: 428-435 www.ijemh.com

stakeholder involvement. The paper adds extent on the integration of 5G and various ADAS applications [8].
In the year 2021, M. Nadeem Ahangar *et al* provides an overview of driverless vehicles and communication technologies. This paper offers a well-defined and in-depth analysis of autonomous vehicles. The addition of 5G-new radio indicates advancements in the field. It describes about vehicular communication technologies. It focuses on technological infrastructure and provides valuable insights on the benefits of these technologies [10].

In the year 2022, D. G. Morín, P. Pérez *et al* discuss the augmented reality technology with 5G networks. It defines the impact on future of mobile applications. The role of 5G networks has been evaluated which provides value to the paper. It also offers a roadmap for the improvement of AR applications. The paper's conclusion is succinct and summarizes the main findings effectively [13].

III. EXISTING MODEL

1. LEVELS OF ATANOMY

There are six levels of automation ranging from no automation (Level 0) to complete autonomy (Level 5) as delineated by the Society of Automotive Engineers (SAE).In figure 1, the functionalities of each level has been described. These levels provide a structured framework for comprehending the role and capabilities of driver. The levels are as follows:

- **Level 0:** This level is reviewed as no automation level. It is solely controlled by human lacking the use of automation assistance. The decisions regarding driving, acceleration, road usage and steering is taken by human.
- **Level 1:** This level focuses on selective functionalities and provides assistance to a limited range. Adaptive cruise control or lane-keeping control is accessible in this level. However the overall control is secured by human.
- **Level 2:** Two or more functionalities can be concurrently controlled. Both steering and acceleration can be controlled at the same time. Nevertheless, the driver must be prepared and mindful to take over any time.
- **Level 3:** This provides conditional driving. Vehicles are capable of driving on its own under definite condition, like highway. The driver may not drive but should remain attentive to take over when required. It is conditionally autonomous.
- **Level 4:** These vehicles are highly automated. It operates within a specific operational design domain (ODD). This includes monitoring the current environment for detection and defines geographic areas.
- **Level 5:** These are fully autonomous vehicles. They operate without any human intervention. They are designed to handle all aspects of driving, without the requirement of control inputs.

Fig 1: Levels of automation (.(https://doi.org/10.1016/j.vehcom.2022.100551)

2. CONVOLUTIONAL NEURAL NETWORKS:

It is a specialized type of neural network engineered for analysing structured data, visual perception tasks. This network draws inspiration from the human visual system, leveraging layers of interconnected neurons that detect and analyse features hierarchically. Central to CNNs are convolutional strata which apply filters to obtain discernible characteristics like contours and forms present in the input data provided. CNNs improved their parameters to minimize a selected loss function, enhancing their performance across a range of computer vision assignments like image classification and object localization. CNNs is a foundational tool for data interpretation.

3. RECURRENT NEURAL NETWORKS (RNNs) AND LONG SHORT-TERM MEMORY (LSTM):

RNNs and LSTMs excel in anticipating the future paths of the other vehicles on the road by leveraging past data. RNNs can be applied to emulate driver behaviour by training on driving data, facilitating autonomous vehicles to mimic actions akin to those of human drivers. RNNs and LSTMs assist in amalgamating information from diverse sensors, providing vehicle localization information through the fusion of sensor inputs. RNNs are leveraged for processing verbal or written directives from passengers or interact with external components, enabling

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 4, Issue 5, Sep.-Oct., 2023 pp: 428-435 www.ijemh.com

improved communication and synchronization in autonomous driving contexts.

4. EXISTING ARCHITECTURE

Autonomous Connected Vehicles (ACVs) integrate multifaceted technologies for inter-vehicular connectivity, improving roadway safety and traffic efficiency. The architecture of ACV can be illustrated as shown in figure 2. Communication is done through Controller Area Network (CAN) buses and infrastructure. ACVs are central emphasis of research, motivated by the goal of road safety, optimizing traffic flow, and reduce fuel consumption. The structure involves three tiers: perception, planning and control, enabling data fusion, management of actuators. Communication channels like V2V and V2I play an important role. Sensors in ACVs facilitate object detection. ACV deployment encounters challenges concerning the efficient connectivity among vehicles, infrastructure and road users.

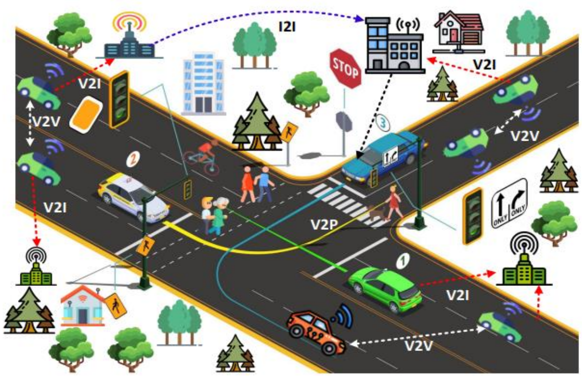

Fig 2: Illustration of Autonomous Connected Vehicles, Infrastructure, Environment and Communication.(https://doi.org/10.1016/j.vehcom.2022.100551)

IV. Emergence of new technology

A. Evolution of AR

AR is the incorporation of virtual objects in the material [2].The first AR was developed in 1960s which was represented as 3D graphics. The term “augmented reality” was coined by Caudell and Mizell in 1990 [1].With the increasing demand for interactive experiences, AR has a major role among the users in this generation.AR is used in various industries like education, gaming, healthcare, retail and manufacturing.

B. Evolution of 5G technology

5G technology refers to the fifth generation mobile technology. In the early 2000s, as 4G networks were rolled out, scientists have envisioned about the future where communications will be more easy and reliable. As the need of smart phones, iot devices and other technologies was increased, there was a growing demand for faster communication to overcome the data traffic. The research was started and lead by many research and development centres conducting various testing and trials to explore the capabilities of the technology. By the late 2010s the first rollout of the commercial 5G networks commenced in different regions across the globe. Initially it was available in selected cities but as infrastructure development has increased, its availability was expanded to a wide range of areas. South Korea was the first country to adopt the 5G technology. In figure 3, The Mobile networks have evolved up to 5G for several key reasons like broadband, reliability and efficient connectivity. It was developed to address the limitations of existing 4G and 3G networks.

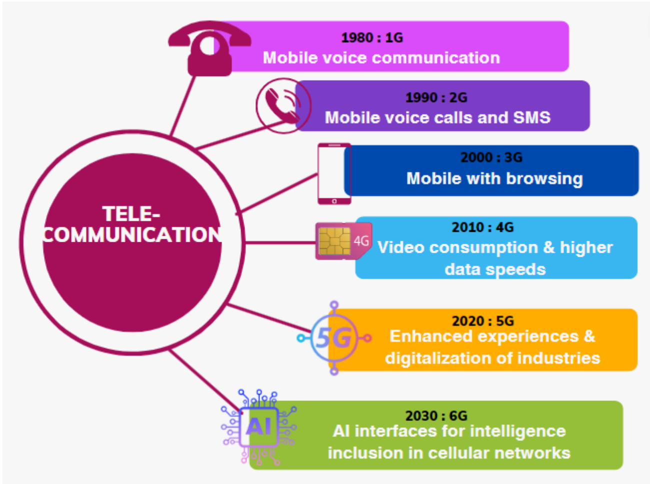

Fig 3: Telecommunication evolution

C. Evolution of autonomous vehicles

The abstraction of autonomous vehicles traces back to the 16th century when Leonardo da Vinci crafted a petite, 3-wheeled, autonomously moving carriage. In 1925, an electrical engineer from New York was the first person to bring out the concept of autonomous vehicles. In 1980, a Mercedes-Benz van was converted into a self-driving vehicle by Ernst Dickmans who is known as the father of autonomous vehicles. This vehicle made a significant achievement by travelling 63kilometers per hour through the streets with no traffic. As of 2021, there is no fully autonomous vehicles available for purchase. Tesla is the only company with its full self-driving package that is close to the autonomous vehicles in the market. Nevertheless there are many autonomous vehicles in the industries like mining where it is successful. The Autonomous Vehicles are the core elements in the innovative solutions for propagating Intelligent Transportation System [5].In figure 4, User studies

International Journal of Engineering, Management and Humanities (IJEMH)
Volume 4, Issue 5, Sep.-Oct., 2023 pp: 428-435 www.ijemh.com

focusing on the assessment of autonomous vehicles are depicted.

References	Topic	Displays used	Vehicle automation	Dependent Measures
McGill et al. (2017)	*Visual motion cues*	*HMD*	L3-4	*Rating*
Sawabe et al. (2017)	Vection illusion	*HMD*	L5	*Vection*
Hanau and Popescu (2017)	*Visual cues*	*HMD*	L5	*Rating*
Williams et al. (2020)	*Visuo – haptic feedback*	*HMD*	L0-2	*Driving time*
Lucas et al. (2020)	*Seat vibrations*	*HMD*	L5	*Postural stability*
Jinjakam and Hamamoto (2013	*Parallax, Position, height & difference*	*CAVE*	L0-5	*Speed, acceleration*
Karl et al. (2013)	*Simulator sickness while driving*	*HMD*	L0-2	*Braking*
Benz et al. (2019)	*Comparison projector vs HMD*	*HMD, Monitor*	L0-2	*SSQ*

Fig 4: User studies related to simulator and motion sickness application area

V. Implementation

Our implementation would be AR integration in 5G powered autonomous vehicles. And it's overview is given in figure 5. Autonomous vehicles rely on camera and sensor based technologies. These vehicles are highly reliant with sophisticated infrastructure which specializes maps and lanes. In the figure 5, integrating AR would present a myriad of benefits in terms of safety, navigation and user experience. Implementation steps are as follows,

Network connectivity: Ensure the establishment of a robust 5G network infrastructure to adequately meet the high-speed data transfer demands of autonomous vehicles and augmented reality applications. Team up with telecom firms to develop a robust 5G network that enables minimal delay communication between the cloud, autonomous vehicles and AR devices.

Automotive components and sensor incorporation: Equip the autonomous vehicles with LiDAR, radar and cameras to collect real-time data and detect the surroundings precisely. Incorporate hardware components compatible with 5G connectivity to establish a seamless and continuous flow of data between the vehicle and cloud-based services.

AR Framework: Evolve AR interfaces within the vehicle that imposes pertinent data onto the windshield or personalized AR glasses for the driver and passengers. Implement high-definition displays with minimal delay to ensure a seamless and immersive AR experience, enhancing navigation, entertainment, and safety features.

Live data streaming and handling: Establish a resilient real-time data transmission and processing framework that harnesses rapid data transfer and near-zero latency advantages offered by 5G networks. Optimize the usage of edge computing to enable faster data processing in proximity to the data source and diminishing the need for remote data transmission to centralized servers, by decreasing latency. Consequently, it enrich swift-decision making for both autonomous vehicles and AR.

Enhanced AR-Assisted Guidance and Safety Features:
Develop an AR-based navigation system that offers drivers up-to-the-minute data about their surroundings**,** including live traffic updates, local attractions, and real-time navigation prompts. Integrate AR overlays in the vehicle's dashboard for real-time safety alerts like precise lane guidance and sophisticated crash alerts. This enhances defensive 'driving and reliability of autonomous driving systems.

Interactive AR experiences: Enable collaborative AR experiences that allow passengers to engage with the surrounding providing information about landmarks, and nearby attractions. Enable seamless communication and data sharing between multiple AR devices , fostering a compelling and captivating experience throughout the journey. This allows people to enjoy an immersive journey, where they can collaborate and interact with augmented reality.

Confidentiality protocols: Enhance robust security protocols to safeguard the transmitted data between vehicles, and the cloud infrastructure. Adhere stringent privacy guidelines and regulations to protect user information and restrict unauthorized access to sensitive data. This leads to upholding instituted legal and ethical standards, utilizing encryption techniques. This creates trust and confidence in the handling of user data.

Perpetual testing and Enhancement: Perform rigorous testing of the integrated system to identify any potential issues to connectivity, data processing or user experience. Gather user feedback from users and leverage the data to consistently enhance the performance, reliability, and user friendliness of the integrated autonomous vehicle and AR system. This improvement fosters a user- centric approach, which increases user satisfaction and optimizing performance.

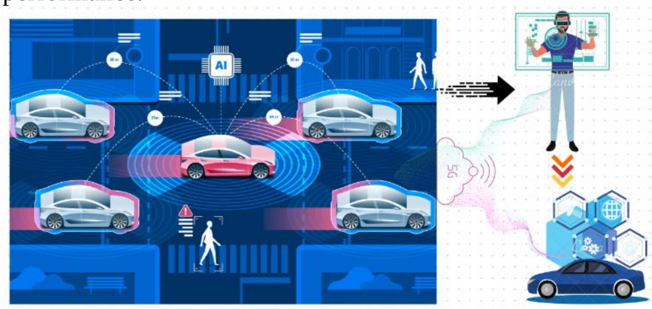

Fig 5: Overview of integrating autonomous vehicles with augmented reality using 5G technology

1.COMPONENTS

In figure 6, LiDAR (Light Detection and Ranging): This sensor is used to create precise, real-time 3D mapping of the vehicle's surroundings. These sensors are connected to the vehicles through a data interface that transfers live 3D mapping information to the vehicle's central processing unit. This sensor emits laser pulses, which bounce off nearby objects before returning to the sensor. The main purpose involves detecting obstacles, pedestrians and other vehicles within the vicinity.

Fig 6: Magnetic Sensor Black MRS1104C-111011 3D LiDAR Sensors, For Object Detection, Closed

In figure 7, Radar sensors are instrumental in discerning the distance, speed, proximity, velocity, and direction of objects around the vehicle especially in poor visibility conditions like fog or heavy rain. These sensors are connected via Controller Area Network (CAN) bus to communicate with the CPU. The sensors emit radio waves to measure distance, speed and direction.

Fig 7: Radar Sensor (by Fraunhofer-Gesellschaft JUNE 3 2019)

In figure 8, Inertial Measurement Unit (IMU) plays a vital role in capturing the vehicle's specific force, acceleration, angular rate and sometimes the magnetic field which empowers the vehicle to comprehend ots own movements and position.

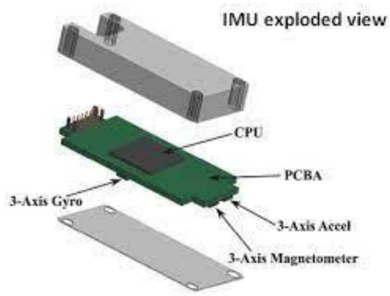

Fig 8: IMU with a three-axis accelerometer and three-axis rate sensor. 9-DOF units include a three-axis magnetometer.(AUGUST 15, 2018 BY LEE TESCHLER)

VI. EXPERIMENTAL RESULTS

Network connectivity is essential for operation and security of autonomous vehicles. It empowers real-time data transmission, vehicular and infrastructure connectivity, access to cloud services. It obtains software patches and remote assistance when needed. Automotive components and sensor incorporation is used for identifying obstacles, navigating and making decisions. It enables safe and autonomous operation of vehicles. The AR framework enhances the driving experience by superimposing pertinent details, cautionary notifications, and entertainment onto the driver's field of view. Live data streaming and handling provides real time decision making. It also responds to dynamic traffic conditions and enhances the experience. Enhanced AR-Assisted Guidance and Safety Features deliver up-to-the-minute, context-aware information that improves safety and guidance. These features revolutionize the way people communicate and experience their surroundings while driving. Interactive AR experiences leverages augmented reality technology which creates interactive relationship between vehicle's occupants and external world. Confidentiality protocols secures data, safeguards communications and protects the privacy of passengers. Perpetual testing and Enhancement guarantees that autonomous vehicles stay current, safe and operate efficiently making them more viable for everyday usage.

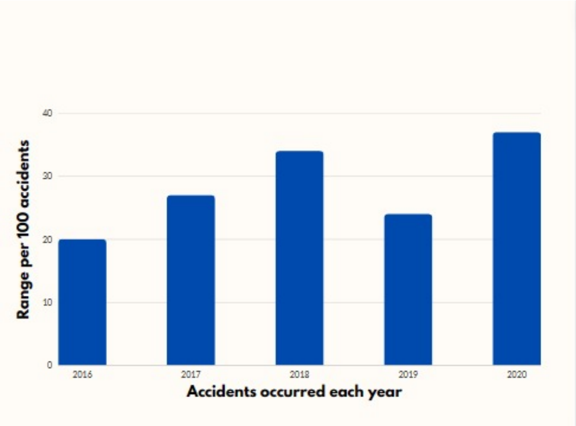

Fig 9: Annual incidence of accidents attributed to conventional vehicles

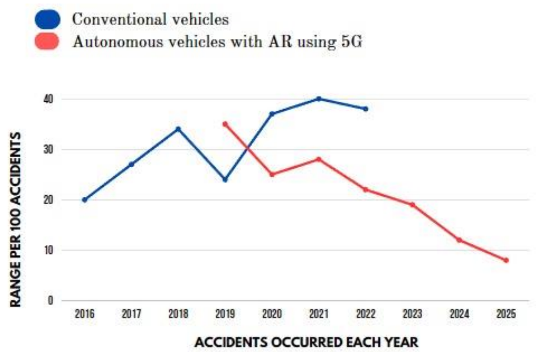

Fig 10: Graph depicting the comparative impact of accidents involving 5G-enabled AVs with AR and conventional vehicles.

VII. CONCLUSION

Further in autonomous vehicles, we can integrate more advanced collision avoidance systems with AR. This could include the enhancement of the system's ability. One can develop AR applications to support vehicle maintenance and repair.AR glasses can be used to retrieve diagnostics and maintenance guidance. AR can used to entertain passengers. We can enable to assist with emergency response situations. It can help and provide guidance in case of emergencies to passengers. We can try and implement integrating weather updates. One can implement voice recognition and language processing for AR interactions, which should allow passengers to communicate with the system more efficiently.

REFERENCES

[1] Charvi Agarwal and Narina Thakur "IJCSI International Journal of Computer Science Issues" , Volume 11, Issue 6, No 1, November 2014.

[2] M. Billinghurst, A. Clark, and G. Lee, Foundations and Trends in HumanComputer Interaction, 8, 73– 272 (2015)

[3] Seung-Hwa Jun, Jung-Ho Kim "5G will popularize virtual and augmented reality: KT's trials for world's first 5G olympics in Pyeongchang". ICEC '17: Proceedings of the International Conference on Electronic CommerceAugust 2017Article No.: 4. (2017)

[4] Pengyuan Zhou, Wenxiao Zhang, Tristan Braud, Pan Hui, Jussi Kangasharju "ARVE: Augmented Reality Applications in Vehicle to Edge Networks" .Association for Computing Machinery New York, NY, United States. (Published:07 August 2018).

[5] Khazraeian, S., Hadi, M. (2019). Intelligent Transportation Systems in Future Smart Cities. In: Amini, M., Boroojeni, K., Iyengar, S., Pardalos, P., Blaabjerg, F., Madni, A. (eds) Sustainable Interdependent Networks II. Studies in Systems, Decision and Control, vol 186. Springer,Cham.

[6] P. Zhou, W. Zhang, T. Braud, P. Hui and J. Kangasharju, "Enhanced Augmented Reality Applications in Vehicle-to-Edge Networks," 2019 22nd Conference on Innovation in Clouds, Internet and Networks and Workshops (ICIN), Paris, France, 2019, pp. 167-174, doi: 10.1109/ICIN.2019.8685872.

[7] Hyunbum Kim; Jalel Ben-Othman; Lynda Mokdad; Junggab Son; Chunguo Li "Research Challenges and Security Threats to AI-Driven 5G Virtual Emotion Applications Using Autonomous Vehicles, Drones, and Smart Devices". Published in: IEEE Network (Volume: 34, Issue: 6, November/December 2020).

[8] Chandupatla, S., Yerram, N., and Achuthan, B., "Augmented Reality Projection for Driver Assistance in Autonomous Vehicles," SAE Technical Paper 2020-01-1035, 2020, https://doi.org/10.4271/2020-01-1035.

[9] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier and B. MacIntyre, "Recent advances in augmented reality," in IEEE Computer Graphics and Applications, vol. 21, no. 6, pp. 34-47, Nov.-Dec. 2001, doi: 10.1109/38.963459

[10] M.Nadeem Ahangar, Qasim Z.Ahmed, Fahd A.Khan, Maryam Hafeez "A Survey of Autonomous Vehicles: Enabling Communication Technologies and Challenges". Volume 21 Issue 3 10.3390/s21030706 (2021).

[11] Deepender, Manoj, U. Shrivastava and J. K. Verma, "A Study on 5G Technology and Its Applications in Telecommunications," 2021 International Conference on Computational Performance Evaluation (ComPE), Shillong, India, 2021, pp. 365-371, doi: 10.1109/ComPE53109.2021.9752402.

[12] Madoka Inoue, Kensuke Koda, Kelvin Cheng, Toshimasa Yamanaka, Soh Masuko "Improving Pedestrian Safety around Autonomous Delivery Robots in Real Environment with Augmented Reality". VRST '22: Proceedings of the 28th ACM Symposium on Virtual Reality Software and TechnologyNovember 2022Article No.: 63. (2022).

[13] D. G. Morín, P. Pérez and A. G. Armada, "Toward the Distributed Implementation of Immersive Augmented Reality Architectures on 5G Networks," in IEEE Communications Magazine, vol. 60, no. 2, pp. 46-52, February 2022, doi: 10.1109/MCOM.001.2100225.

[14] Saqib Hakak, thippa Reddy Gadekallu, Praveen kumar Reddy Maddikkunta " Autonomous vehicles in 5G and beyond: A survey" Vehicular Communications Volume 39, February 2023, 100551.

[15] O. El Marai, T. Taleb and J. Song, "AR-Based Remote Command and Control Service: Self-Driving Vehicles Use Case," in IEEE Network, vol. 37, no. 3, pp. 170-177, May/June 2023, doi: 10.1109/MNET.119.2200058.