AI-Based Systems for Autonomous Vehicle Communication and Coordination

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1. Introduction

The AI software discussed includes abstract control models of cooperative automated vehicles, hybrid AI techniques for traffic management, AI-enhanced vehicle communication, hybrid and cooperative wireless communication for vehicular networks, and networking technologies for cooperative intelligent transportation systems (C-ITS). The AI hardware includes AI-enhanced System-on-Chip (SoC) vehicle solutions, dynamic sensor reuse for advanced driver assistance systems (ADAS), hardware and field-programmable gate arrays for automotive end-to-end wireless communication, disruptive communication hardware technologies, ruggedized embedded and edge AI processors, roadside AI acceleration technologies, AI hardware virtualization, and sensor/actuator technologies for real-time mobility. The AI-enabled IoT technologies include convex-optimization with Bernoulli-distributed observed round trip time, parallel microsecond drive-by-wire protocols, AI-supported connectivity solutions for cooperative intelligent transportation systems, ultra-reliable and low-latency communication solutions, V2X-ML enhancement in IoT, 5G advanced radio access network enabling broadcasting, and vehicular sensor and actuator data processing.

[1] This report summarizes studies and reviews on AI-based software, hardware, and Internet of Things (IoT) technologies that enable safe, cooperative, and efficient vehicle communication and coordination without human intervention. Traffic accidents caused by human errors continue to occur despite advances in vehicle safety technologies, such as advanced driver assistance systems (ADAS) and emerging autonomous vehicles (A-Vehicles). These developments aim to reduce the number of road traffic accidents and fatalities in Europe and other regions. The road safety issues raised by advanced autonomous vehicle architectures have given rise to interesting challenges and research opportunities in AI.

1.1. Background and Significance

To address the heterogeneity of connected traffic users and to enhance the performance of autonomous and cooperative systems under unforeseen permutations of road environmental conditions, vehicle autonomous systems can be designed as a combination of two main modes of intelligent operation [2]. Specifically, vehicles can be empowered to operate over a wireless network in a cooperative fashion, acquiring information about the traffic environment that is not directly visible from their on- board sensors. When network connectivity is available, autonomous cooperative systems can essentially act as though the traffic environment is deducible based on the combined sensor information across all of the roadside and/or vehicle- borne agents. On the other hand, when the network is not fully functional or otherwise available, e.g. due to sensor limitations and non-stationarity of the trafficenvironment, intelligent vehicles need a fall-back solution to execute Vehicle autopilot control in response to sensor data alone. These alternative decision-making strategies can curtain cooperative rules and execute semi-centralized and/or decentralized vehicle autopilot and traffic monitoring strategies that are based on individual vehicle sensor data only.

Heterogeneous road user-specific characteristics are unforeseen changes in traffic environments that restrict the performance of cooperative systems. Poor network connectivity, manipulation, and malicious attacks limit system performance. Cooperative systems have an urgent demand for network robustness and security strategies. Sensing is an alternative source of environmental data. This is based on sensing the surrounding environment to detect and identify road users and evaluate the signal-to-noise ratio for communication challenges are highlighted [3]. Connected and autonomous vehicles (CAVs) are two crucially evolving technologies that are expected to transform the future of intelligent transport systems (ITS), in terms of the safety, environmental impact, and efficiency of road-based transport. According to several studies, the ability of autonomous vehicles (AVs) to communicate over a network will result in improved road safety, lower traffic congestion, and optimized vehicle fuel consumption and emissions, among other performance metrics.

1.2. Research Objectives

Therefore, after understanding the motivation behind working on AI-based systems for autonomous vehicle communication, below we present the objectives of the section. The interconnected autonomous software that controls AGVs in the port will be examined with respect to the use case of this article. The functionalities addressed in this article will cover perception abilities enhanced with communication and system design alternatives and implementations for those who are interested in providing a complete system that is able to control AGVs in cooperation with each other safely and efficiently. Further, considering the port management system, it is natural for multiple fleets to be used in the same port. Finally, to infer how separated sub-systems could be utilized, a general port management framework is presented along with the current literature.

In recent years, autonomous vehicle communication as a research topic has been gaining momentum, especially with emerging concepts such as connected and cooperative autonomous vehicles. The connected autonomous system works on the assumption that autonomous vehicles could communicate with each other, the infrastructures and adopt a suitable algorithms, while cooperative autonomous system is typically about solving a mission or performing a task with the minimal shared information, so that the data communication is not mandatory, and it is mainly about the cooperation between agents. As car manufactures have been continuing the efforts to manufacture vehicles with increasing automation levels, many of today's autonomous vehicles are expected to be "interconnected". This type of cooperation concept also holds for the scenario that today's port management system is facing, in which vehicles can cooperate with less use of infrastructure, and coordinating multiple automated guided vehicle (AGV) fleets in an efficient manner is challenging. Although numerous research in the literature propose to develop and adopt AI-based approaches to alleviate these challenges, the current research still lack an inter-area review to discuss the requirements, potentials, and research status of this topic.

2. Fundamentals of Autonomous Vehicles

A simplified network control system diagram of a fully automatic vehicle system is shown in Figure 1 [4]. Specially designed electric or pneumatic actuators for acceleration, selection, and energy derivation are used. The decision is made through data acquisition such as variation of the access road and the vehicle's own driving status. The cheapest solution to realize effective communication on vehicles is to use cooperative V2V. Traffic jam situations in a field where a vehicle is operated should be viewed as large obstacles that provide a suggestion about whether to avoid the new path and provide an opportunity for the vehicle operator to take positions in the same lane. A combination of the first three methods can be seen as a mutually productive trend. If communications between the V2I systems and vehicles no longer work due to biogenic or intentional extraordinary conditions, it should be clear for the autonomous vehicle that it can still be stopped or continued in a controlled manner. Just as an automatic driver aiming to take the vehicle off the street or stopping at an emergency location.

Autonomous vehicles (AVs) have been recognized as the ultimate traffic scenario, promising to save thousands of lives and millions in costs related to injuries and material losses, saving fuel and reducing emissions due to smooth driving, and enabling more enjoyable working or resting time during transportation [5]. The dependence of communication between vehicles and the wireless roadside units will increase as integration into the Internet of Things and 5G communication technology develops. The technological development of automatic coordination and accident avoidance systems through decentralized cloud communication infrastructure development based on artificial intelligence (AI) techniques is also included in the application areas of vehicle-to-infrastructure (V2I) [6].

2.1. Definition and Types of Autonomous Vehicles

In terms of technological capabilities, AVs require reliable mechanical architectures and next generation and emerging technologies, while the concept of AI encompasses aspects of AV control, perception, interaction, communication, and coordination [7]. There are multiple types of autonomous robotic vehicle architectures that exist, all pointing towards unique vehicle classification taxonomy that is currently under development. The academic, defence and public sectors have arrived at different classification schemas. The Air Force Research Laboratory (AFRL) has deployed the Tactical Autonomous Combat CHallenge (TACX) vehicles, where TACX targets a near-term, uncertainty capable Unmanned Ground Vehicle (UGV) architecture. The Automated Ground Control Station (AGCS) is developed in TACX. At the opposite spectrum is the Long-Term Autonomy and Mobility Division (L-TAM) of the University of Pennsylvania. Long-Term Autonomy spans time scales of hours to months and does not rely on any communication or human intervention to operate and is designed for US Army robotic convoying standard testing. All systems operate in off-road conditions rather than constrained highway driving conditions and the platforms are typically heavier, with increased computing power. Preliminary studies show that robots with enhanced sensing can significantly enhance the performance of nominal convoying operations with respect to availability.

The requirement for AI-based systems for autonomous vehicle communication and coordination has been rapidly risen in response to the significant potential societal and economic impacts, such as reduction in traffic congestion, pollutant emissions, noise pollution, accident rates, and guaranteed mobility for a wide range of drivers, including the elderly, disabled, and legally blind [8]. Autonomous vehicles are defined as vehicles that are capable of driving in various environments or locales without human intervention [9]. This field occupies a diverse application landscape that includes military, industrial, and farming applications. The key development driver for autonomous vehicles in the public and private domain has been consumer passenger vehicle applications. This use case is estimated to yield significant benefits to society, including reduced road accidents given major efficiency improvements as it pertains to traffic jam avoidance and energy conservation. To progress towards a future-stage Autonomous Vehicles (AV) Transportation system, three key changes are required: increasing public awareness, modifying road infrastructure, and conducting AV reliability and legality tests.

2.2. Key Technologies and Components

The components of the AI-Based system for communication and coordination of autonomous vehicles are not limited to AI on-board supervisor and onboard agents. There can be applications that communicate and evaluate the quality of links with the overhead infrastructure. There can be agents designated as safety drivers of manually controlled vehicles. The modes of information transmission among vehicles and communication quality can vary also. They will be referred to "communication primitives," and the contrary mode "primitive distributions" are referred to in. The platform of the applications and their mode of information transmission is to a certain degree vehicle-related. Also, they are related to the active traffic environments in a neighbourhood. The acronym AI (Artificial Intelligence) refers to the system with a decision-making process, which keeps the vehicle within the intended ODD, avoids conflicts, fulfils other requirements (see (e.g.)) and decreases the level of the risk generated by the system.

[The vehicles' operating environment can be seen from the perspective of each vehicle as well as from the perspective of other vehicles in the vicinity. From the link perspective, each vehicle can communicate with other vehicles and the infrastructure [10]. The ability to communicate over fixed and mobile networks alongside the vehicle's on-board intelligence in AI is considered an important technique. The onboard intelligence acts as a decision-making mechanism. The onboard supervisor and the agent distributed systems exchange their information with their counterparts in other heterogeneous systems, as shown in [2]. As shown in [11], the author considers the isolated operation of an AI-based system; this vehicle's ability to operate safely in an AI domain over the desired time produces only low risk to involved traffic participants, infrastructure and the AI system itself.

3. Communication Protocols for Autonomous Vehicles

Standardization groups such as IEEE and 3GPP standardize and coordinate the communication field of information regarding cars and communication, and hundreds of papers on these topics are published in joint field of dependable system communication and V2X technology and electrical system. IEEE also organized the 1609 Intelligent Transportation Systems (ITS) standardization group for vehicular communication, and 3GPP (Third Generation Partnership Project) was referenced as the ETSI TC ITS (Intelligent Transport Systems) standardization group. ITS-G5 (IEEE 1609 WAVE) technology defined by IEEE and LTE-V2X technology standardized by 3GPP are mainly used throughout the vehicular communication research and its comprehensive range of fields. The field uses thousands, the number of patents, and customers of this area are growing rapidly [12].

Text generation consists on finding the most appropriate AI model to match the criteria provided. In this case, we use GPT-3. Here is the result: Vehicular communication has attracted attention as a general and effective method to safely and efficiently improve future autonomous vehicle (AV) operation by sharing information between vehicles. Various technologies such as dedicated short range communication (DSRC) [13], LTE communications and Wi-Fi are considered for vehicular communication, and even V2X (Vehicle to Everything) is considered as it collaborates with infrastructure communications. Such vehicular communication research covers a wide range of fields. Information exchanged between vehicles about vehicle state for ADAS and AV (Automated Vehicle) collaboration driving, infotainment to improve user convenience, diagnosis and security methods to ensure communication safety, and so on.

3.1. V2V Communication

Although V2V communication is indispensable in the process of intelligent road traffic, the current V2V communication approaches are hurdled by the following limitations: V2V communication compatibility problem, V2V communication congestion problem, and the limitation of V2V communication information coverage, etc. Therefore, the intelligent V2V communication system should be equipped with appropriate V2V communication technologies and strategies to guarantee the feasibility of vehicle collaborative traffic tasks [14]. In addition, due to the complexity of the IV environment, the shortage of the available information, unreasonable settings of the initial stage, and poor adaptability and generalization, the original approach may not adapt well to the vehicle trajectory prediction scenario, and there are more significant constraints when the trajectory prediction of the vehicles is further extended to the vehicle collaborative traffic task. To deal with the problems of vehicle trajectory prediction, adaptive parameter setting, accurate model-driven generalization, and low adaptability of vehicle platooning, the research on the proposed V2V communication method should be further more in-depth.

The Internet of vehicles (IoV) is an intelligent traffic system achieved by connecting vehicles with communication technologies, measuring procedures of intelligent control and management. It emphasizes the comprehensive management of civilian vehicles, ensuring vehicle sensing, perception, communication, decision making, and execution in advance. Vehicular-to-vehicular (V2V) communication is an indispensable part of the IV system, and it has the following advantages: fast response speed, controllability, continuous empirical verification, and decision-making support, etc. The realization of intelligent transportation requires V2V communication achieving the typical vehicle collaborative traffic tasks such as vehicle collaborative platooning, emergency braking, and destination-based traffic light priority [10].

3.2. V2I Communication

Although relevant works proposing intelligent systems for searching for parking spaces exist, none have previously proposed a real-time parking reservation and digital payment system. In addition, little attention has been given to end-to-end solutions, as the current state-of-the-art technologies have considered parking in parking lots only. The contributions of this article are as follows: (1) We propose a real-time parking reservation and digital payment system for inroad and public parking. (2) The system considers both traffic signal and parking, providing end-toend solutions to decrease traffic congestion and lung cancer caused by noxious gas. (3) Performance evaluations are conducted to evaluate effectiveness. Only ahead of the study were observed in the secure technologies available in advanced countries above 4 k–2 m-120 m waiting for default parameters and 1 hp for 7 min in traffic flow.

Parking Assistant Systems (PASs) can provide drivers with suggestions on where available parking space can be found based on real-time data. Each parking lot may be equipped with the latest sensor technologies to alert drivers to available spaces and to make them aware of which aisles/corridors can be utilized to avoid congestion. Traffic lights can communicate in real-time with vehicles in their vicinity to achieve efficient traffic movement. This information can be used to implement a system that gives signal priority while considering both public and private transportation. V2I are capable of transmitting information like weather, village tourism, route congestion information, and other roadside service data directly to the vehicle [15]. The information collected by V2I communications can help drivers obtain relevant information and services like hotel accommodation suggestions, gas station locations, and more. To comply with the future high-quality routine traffic and logistics system, the parking lanes and toll gates were configured with RFID devices, the upstream and downstream control modules are established, and unmanned parking management is realized. At the same time, the vehicle-centered traffic signal rapid ahead of arrival model proposed, the correlation test flow was conducted, and the technology further simulates the application of high communications to provide the direction and personal experience of the parking lot services and traffic management.

This section focuses on the use of vehicular networks for vehicle-to-infrastructure (V2I) communication. We discuss how V2I technology can be used for parking assistance, signal prioritization, and in providing roadside service information [9].

4. AI Techniques in Autonomous Vehicle Communication

In [16], multiple constraints including safety, congestion, railroad crossing operability, and potential congestion are addressed. The proposed model: (1) predicts lead vehicle behaviour by considering multiple statistical and AI-based prediction methods; (2) models the interaction between AVs and lead vehicles under uncertainty with a new safety- and performance-aware mission planner based on recursive mission planning; and (3) ensures safety and legality in conflict zones through the joint distribution planning and velocity scheduling of AV fleets based on evolutionary multi-objective optimizatio.

The increasing congestion of highways and road networks in urban and rural areas is a major challenge for the modern world. Smart urban mobility scenarios for new generation transportation systems lay the basis for improving the smart vision model. A significant part of urban smart mobility applications is related to connected vehicles, and in particular, autonomous vehicles (AV). In [14], the main contribution is to illustrate the application of the new technologies for autonomous vehicle behaviour prediction in the presence of vehicle and pedestrian as well as during a highway merging scenario. Machine-learning algorithms are crucial in reaching real-time behaviour prediction and thus, to ensure the safe driving of autonomous vehicles.

4.1. Machine Learning and Deep Learning Applications

VANETs are models of Mobile Ad-Hoc Networks (MANET), with the distinction that nodes in VANET are able to exchange road related information and data. Autoencoder (AE), a well-known deep learning model, is a distinctive choice relying on combining supervised and unsupervised learning mechanisms as well as to improve the training time by compressing the input and reconstruction at the output [17]. In the future networks, AEs can be utilized in the mobile edge servers to compress the communications and minimize the latency. In another research work, similar to AE, researchers implemented Variational Autoencoder (VAE) in the middle of the communication links to improve communication.

Machine learning (ML) provides the computational algorithms for computers to learn from experiences, increase performance with experience, and learn from a database consisting of previous cases. ML algorithms have made it possible for vehicles to automatically adjust steering, illumination, and tire pressure in the event of electric failures, as well as to diagnose and fix vehicle faults through predictive maintenance applications [18]. Deep Learning (DL) is a representative subfield of ML and deals with learning from extensive data, which can be also beneficial for the conception of AI algorithms that can work without relying on human proficiency [19]. An advantage of DL is the ability to execute machine learning in a smart manner, without the need for the specification of evident features because DL can automatically seek the prominent features. In fact the technologies of deep learning and machine learning enable the classification of network traffic and the optimization of Vehicular Ad-Hoc Networks (VANETs) to these technologies.

4.2. Reinforcement Learning for Decision Making

Cooperative autonomous driving can be realized in decentralized methods, where agents make individual vehicle decisions at the same time, or centralized settings, where the communication and negotiation can be further coordinated by a traffic management center

(TMC) or cloud servers and then broadcast to all vehicles participating in negotiations. Despite being able to solve some decision-making problems for autonomous vehicles such as simple lane changing, overtaking, and intersection crossing, no autonomous vehicle decision-making algorithm can fully cope with the complexities of various highly uncertain traffic scenes. In [20], the authors use the deep reinforcement learning method Proximal Policy Optimization to address this problem, presenting a practical agent learning mechanism where cooperative and competitive builders can coexist in a highly mixed, complex traffic scenario, which involves moderated communication and negotiation commands; continuous high-speed overtaking or blocking of other car users in the highway.

In cooperative autonomous driving, automated negotiation among agents could be applied, reducing the implicit uncertainty around the other agents' future behaviors and eventually reducing any unnecessary waiting time and inefficiency in the roadway system. In [21], a 2019 study by Liu et al., the authors learn a negotiation policy by studying equilibria in a non-cooperative game that requires cooperative decisions and a stochastic element, known as a Bayesian mean-field equilibrium. They incorporate the stochastic element using queuing theory and propose coopD-PPO, which performs simulation in a kinematic simulator for the best action selection using policy gradient-based methods. Hence, this solution not only respects the road safety rules and human control habits but also solves congestion in the roadway.

5. Challenges and Solutions in Communication and Coordination

Furthermore, Central Service Control Unit connections are difficult to provide for all. In addition, a provision of all necessary wireless resources for all road users is not feasible among other things due to the high number of road users [22]. The same problems also arise on motorways and rural roads. Similarly, robustness is also missing so far in the sense that with all these technologies such as DSRC and cellular V2X (C-V2X) standards the communication is the weakest point. In April 2019, for example, it was shown that the DSRC wireless standard is not robust, as with inexpensive hardware, in particular with time difference of arrival (TDOA) hardware, the beacons can be completely overdriven with transmitted power at a speed of 50 km/h. Possible attacks with malicious intent on other road users are also conceivable, which is why robust and secure scaling is important. It would be another disadvantage if the C-V2X standards that were standardized on an internationally active standardization body, namely 3rd Generation Partnership Project (3GPP) would not receive the necessary stability. Clearly, with respect to wireless networking, high bandwidth and low latency is needed for ultra-reliable low latency communication (URLLC) problems. Even though directed ultrahigh bandwidth would be formally present, it could still not be guaranteed for each road use case. With regard to content security, especially safety data must be authenticated in order to be guaranteed, then later a controlled action can be externalized [3].

Autonomous vehicle systems need to move from targeting autonomy to embracing cooperation [6]. Current trends in vehicular communication such as the 4G Long Term Evolution (LTE) are not designed to support a high density of communication devices and do not take the control theoretical perspective of communication systems into account. Such coordination has so far been hampered by several challenges: The road user density in cities necessitates public V2X infrastructure. Special solutions are needed to counter the scarce infrastructure in the city. During large public events such as football stadiums, events, or concerts, the usage of public cell radio networks could not be guaranteed for all. Experience shows that even with current solutions such as 4G Long Term Evolution (LTE), high data rates can no longer be achieved. At sports events or other events the operators of telecommunication sites can increase the capacity too. However, this is inflexible due to the non-flexible and partially temporary infrastructure.

5.1. Security and Privacy Concerns

The perception of the environment by all the equipped vehicles will rely quite heavily on the reception of relevant V2X messages. Otherwise essential functionalities for definite road safety such as collision avoidance, lane keeping assistant, travel time estimation or choice of future speed profiles will become very costly and less than the predictions about the road safety levels in the era of autonomous automobiles. This situation confirms the importance of ensuring the uninterrupted flow of information between and among different types of automated cars, work tools, joined driving behaviors and regular manual vehicles. Assuring an appropriate level of security is the primary issue that has to be taken into account. Evasive safety rather than risk reduction as in automotive safety mandates more robust communication networks. Safety messages are critical messages, their trustworthiness, security and privacy leakage and reliability play crucial roles for the effectiveness of future road safety systems with a possible wide range of accessibility. Consequently, security in connected and automated vehicles is inseparably connected with achieving the highest level of road safety where all basic safety messages have to be fast and future-proof in order to reach effectively all mobile station equipped with V2X [23].

Security and privacy have been important research concerns for future ICT vehicular networks, particularly for intelligent vehicular communications. With the introduction of cellular vehicle-to-everything (C-V2X) technology in 5G (2020-2030), intelligent vehicular communications will emerge as an important enabler for applications such as remote driving and extend communication and local sensing capabilities of automated vehicles. Such communications are utilized for cooperative perception of environmental and traffic conditions. With communication delays and potential threats shaking the trustworthiness of their operations, V2X becomes key for improving security, privacy, and for establishing mutual support between automated and manual vehicular traffic. The "connected security" has given rise to the need for local data processing, cyber-security and privacy protection measures concurrently with further development of communication technology [24]. It is expected that a host of third-party service providers including security, cybersecurity, and other software developers, telecommunication companies, and public transportation operators will provide additional support for smooth traffic control and more secure and efficient future mobility. However, under very realistic assumptions, it has been established that safety requirements in autonomous transportation can be met only if V2X technology, which is a part of V2V and V2I, guarantees the lowest latency and the highest reliability of all traffic participants [25].

5.2. Interoperability Issues

Thus, the field requires integration of sophisticated control systems with intelligent, self-adapting, and resource-aware software systems for coordination and cooperation. Similarly, future wireless communication systems require coordination to enable access to the most suitable and desired resources under cooperative scenarios. This introduces the need for robust and secure control mechanisms on both sides of these wireless communication links. Furthermore, for competing wireless nodes to understand "what sort of network they are in" and to act accordingly, it becomes necessary to integrate control systems with AI-based perception and learning systems for self-awareness of the system environment [26]. While the AI enhancers can carry out a lot of low-level resource optimization, we argue that the coordination of two or more autonomous systems always allows to achieve a more optimal global behavior. Cuts in the problem space can be achieved when, for instance, separate decision maker A and B are able to decide "A has a better idea" and communicate this to B.

There is a clear need for complex, dynamic, and cooperative use cases, which go beyond the individual autonomy of vehicles and require enough tight cooperation to fall short of describing cooperatively used resources as parts of a single vehicle. This change introduces the need for autonomous systems to communicate and coordinate to enable proper behavior in these collaborative scenarios. This enables autonomous systems to share their objectives and to interact with each other. While the problems are different in nature, both fundamentally rely on successful integration of cooperation into autonomous vehicles, which makes it possible to guarantee that the autonomous systems understand and reliably follow the same rules [27]. Enabling this requires careful coordination between all involved systems, ensuring a consistent understanding of the environment and the team objectives, estimating the effects of the other team members' actions, understanding the implicit and explicit communication of team members, and optimizing the correct behavior. In the given scenario, cooperation then in essence consists of making and following plans that complement each other to achieve global system goals or that hand over work responsibilities to other team members to arrive at partial task completions.

6. Case Studies and Applications

It can be concluded that the use of AI together with communication systems in the transportation sector is extremely important and can prevent accidents, reduce the size and severity of accidents and also lesser the environmental pollutions and fuel consumption. On the other hand, the utilization of AI together with different communication technologies in vehicles increases the real-time operationality and performance. It is also concluded that AI's role is also extremely important due to its quick and efficiency in the connection process. The level of usefulness of AI's contribution in the communication process varies according to the bandwidth. Furthermore, the use of AI may be the most useful in mobile communication technologies.

[1] [14]Advanced driver assistance systems (ADAS) are emerging technologies that help drivers in better controlling vehicles. ADAS, using artificial intelligence, can improve car driving safety and assist car users to have a better driving experience. Base on these characteristics, AI-based ADASs are considered as the bright future prospects for the future

of the transportation industry. AI can make ADASs independent from communication systems for blindly recognition and neutralization of the vehicle-to-vehicle and vehicle-to-infrastructure communications' security attacks. Moreover, AI, using image processing mechanism, can monitor and manage car drivers' fitness and health. It can also recognize drowsiness and interact with driver. This is one of the immense benefits of AI that is being constantly researched and improved for the cars of the future.

6.1. Urban Traffic Management Systems

Both of the approaches: cooperative driving techniques, and the traffic light controls in a cognitive point of view are discussed in this paper for autonomous and cooperative vehicles. An autonomous vehicle cannot be considered as a predictable agent due to imprecise dynamic consideration, and also an emergency situation agent. The main contribution of the paper is to extract the properties and features of natural interactions in the traffic light crossing as an (controlled) intersection and in the Zw guiding systems with respect to the coordination, save some interpretation of what the shared interfaces mean. There is an investigation about the topologic layout at the simulation and large datasets from a base lab and the traffic web from the road area with respect to the adaptive behavior in the view of artificial intelligence and the conclusions are about the approaches of the frame works in the directions – main horizontal, and the full page allocation.

There have been a few practical approaches for urban traffic management systems with respect to autonomous vehicles, as well as some studies in the other aspects among them traffic signals (swapping, time intervals, and so on) [28]. Among the decision-making systems, there are demonstrated cooperative driving techniques and proposed traffic light control systems in the literature. Improved traffic light control systems as the backbone of the urban traffic systems design are discussed in the context of adaptive traffic signal control strategy for different levels of vehicular communications. In addition, there are some studies on traffic optimization for instance from reducing traveling energy and time consumption in traffic jams to vehicle energy minimization, but almost in all the aforementioned proposed strategies and solutions, only moving agents (vehicle, sensors and etc.) are being taken into account, where the semantic impact of the happenings in the vicinity and in the future is not considered.

6.2. Fleet Management Solutions

At present, most consumer-based markets are forecasting an autonomous vehicle percentage of around 50–60%. Autonomous vehicle manufacturers highly recommend centralized fleet management for coordination among different AVs to improve the overall fleet operation and routing. The basic idea behind fleet management is that each AV fleet has a certain geographical division with a precomputed region to ensure the quality of service in the AV market. However, centralized fleet management is threatened by security risks and reliability issues. For example, road-side units can be the target of serious attacks by vehicles. Conditional ε-differential privacy is utilized in [29]. In the paper, fleet management is guaranteed by C-εDP. A commonly used algorithm in fleet management is the k-means clustering algorithm is used to locate an optimal AV fleet in a certain global region, but it has concentrated performance issues in terms of efficiency and costs. Hence, the authors proposed a multi-region k-means (MRKM) is utilized by superimposing some scenarios by simulation in consideration.

Vehicular traffic will increase at an unprecedented rate due to urbanization and the population explosion. To address the impact of congestion and energy inefficiency from traditional traffic management and control systems, connected and automated vehicles have been introduced. Vehicles in traffic can be connected to coordinate with other vehicles and receive information from other vehicles and the surrounding environment through different communication methods, such as V2V, V2N, and V2I (Table 6.2). The communication connection plays an essential role as it integrates wireless technology into transportation systems. In this section, different management and coordination technologies involved in the introduction of smart autonomous vehicles will be discussed [30].

7. Future Directions and Emerging Trends

This survey introduced AI-based and non-AI-based (i.e. traditional) methods in a variety of application knowledge to improve V2X-based unmanned vehicle sensor technologies. Customizing the detection technology mainly with the above detection methods introduces different control methodologies that include different car-to-player awareness technologies in random and crash courses, structured car-to-car awareness broadcast protocols for single- and multi-athlete development courses, and artificial traffic-awareness algorithms for single–collaborative sensors in single and multi-vehicle settings [2]. Additionally, they made the datasets open and updated them with their own dataset._FAILED_An_Implementation_Framework_to_Integrate_Reasoning_and_Action_taking_into_Account_Cognitive_Capacities_Study_Case_of_Self_Driving_Car. The development of V2X sensor technology with edge intelligence methods in this survey can be effective for future automotive applications and prerequisites for low-latency and energy-friendly networking techniques.

Research interests on future AI wireless communication systems are steadily increasing in the area of AI for wireless communication systems. AI can considerably enhance current wireless communication technologies, like 5G, under certain constraints, such as massive traffic, energy efficiency, and ultra-reliable and low-latency access [25]. Notice that the current article discusses an application of M2M or V2X communication technology without distinguishing these technology types. The utilization of low-latency V2X technology has focused our interest in AI methods like decision theory, reinforcement learning, and end-to-end coordinate learning systems. The basis of these methods is mainly socialism and distributed AI. The social method can potentially cover these technologies logic; however, the ST measurements from autonomous vehicles are mostly concentrated on machine learning methods, like deep learning or DNN, and the method performance evaluation in special coordination-challenging problems like a NLOS and highway-based problems in crash course, often requires designed AI models [26].

7.1. Edge Computing for Real-Time Communication

The work proposes to use Modified K-means clustering to map the geospatial distribution of vehicles, and particularly in association with deep-performance-graph-driven reinforcement learning model and fuzzy logic, the cyber twins that are associated with each vehicle is designed for optimal cooperative communication and collision warning. On the other hand, the Intelligent V2X communication algorithms using the idea of global reinforcement learning, game theory, reliability-aware short message service, and edge computing are used to optimize the Vehicle-to-Everything communication at the road side and in the intersections. Smart social vehicle coordination algorithms using global reinforcement learning and communicative collision avoidance schemes can be performed by vehicles as per the edge environment [22].

[31] Since the execution of AI-D enabled applications within the datacenter and cloud require a high latency network connection, edge computing– which provides computing services at multiple distributed nodes along the network as close as possible to data sources– has been proposed as an effective solution to realize real-time communication. For instance, edge computing has been integrated with digital twins in order to provide reliable real-time communication between vehicles and other road participants [32]. The Idea is to propel the integration of computational intelligence with 5G communication (especially Vehicle-to-Everything communication) so as to facilitate effective communication, cooperative collision warning, intersections crossing, social obstacle avoidance, and trajectory coordination at the road side, along highway, and in indoor environments such as garage.

7.2. 5G Integration for Low Latency

As an example which explains the specific need for a tolerable error handling and correction on physical layer and presents 5G solutions for automotive application, here, we consider for the unleashed potential of cloud-based cooperation of a set of sensors and information sources also the level of cooperation already on base layer. All have in common that a more fine granular adaptation of the error handling is desired. Also for information traveling between car and cloud, possible scenarios and communication qualities are many in the structure of autonomous driving and are not covered here. For handheld, we notice that the quality of the produced map by densified information is a first study of interest for path planning. Discuss: The current marketplace for the interplay of 5G in the shadow of the big cloud providers like Google or AWS is a very complex and is a contested place.

The integration of 5G in autonomous vehicles, followed by 5G ultra-reliable and low-latency communication also had drawn attention [33]. The 5G NR enhances reliability and latency for V2X communication. Moreover, 5G provides additional features which can be specifically optimized for autonomous driving, such as flexible sub-carrier spacing, network slicing and improved LDPC coding schemes [19]. In super low latency scenarios, 5G physical layer supports the transmission of safety messages in a few sub millisecond multiple time domain. As raised in the joint paper of the VDE/ITG experts, the potential of 5G network slicing can also be harnessed for automotive scenarios. 5G radio will leverage time-critical service capabilities for mission-critical use case classes – and automotives are among the prime candidates [34]. In addition, just from the demand of the data, with the raising amount of sensor data coming in, cars could be managed with more precision, especially shared sensor data. For such tasks, 5G provides different vehicular safety channels.

8. Conclusion and Recommendations

[1] This comprehensive study provides a review of the development of AI, communications, and the integration of AI capabilities and communication technologies to enhance the safety of real-world applications. We evaluate the role of AI and communication technologies in smart transportation and smart vehicular networks and the measures taken to ensure reliable and safe decision-making in vehicular systems, the safety challenges and threats faced by AI-based wireless communication systems, and methodological and technical aspects relating to AI and communication technologies for assuring safety. We propose systematic recommendations that consider AI based communication technologies as major tools to enhance safety in vehicular systems. The potential contributions and limitations of AI-based communication technologies in the context of vehicular systems are discussed, presenting future directions in the field.[5] This study has reviewed the safety-relevant requirements for AI-assisted vehicular systems that communicate wirelessly, establishing why a lack of proper understanding of the dynamic network environment allows vulnerabilities to propagate. We have addressed how privacy and security can be enhanced by utilizing edge computing solutions and delved deep into the spectrum-sharing and energy-efficiency challenges that arise within a heterogeneous dynamic network. The results of our comprehensive analysis reveal critical factors hindering the safe and reliable exploitation of AI via vehicular systems and encourage future research in light of these shortcomings.

8.1. Summary of Key Findings

This survey has introduced the publications in IEEE, Springer, and ScienceDirect in the search time between 2016 and the first three months of 2021. However, this survey is fundamentally biased towards papers published in proceedings of the IEEE Intelligent Vehicles Symposium and IEEE Intelligent Transportation Systems Conference. These are the biggest and most successful conferences on transportation and intelligent vehicles, and practitioners should consider them as knowledge exposure. The first premier journal on this topic was found in 2020 with reference. The authors may consider reviewing papers from Journal of Field Robotics, IEEE Transactions on Control of Network Systems, Automatica, and Advances in

Transport Policy and Planning. Also, inserting "Internet of Vehicles", and "Internet of Things" as search terms may yield additional papers in the upcoming years.

AI is the fundamental technology for autonomous vehicles as its development and deployment propels applications in perception, localization and mapping, and decision-making [35]. The majority of work in AI for AVs is focused either on perception, localization, and other obstacles because these problems are more common in immediate requirements. However, the collaboration of multiple AVs such as platoons requires developing a complete communication and coordination system by transmitting information and control signals through 5G networks [36]. This survey emphasizes the need for the AI community to contribute work focused on the communication and co-ordination among multiple autonomous cars. The major delinquencies in the contributions on this topic involve the few proposed algorithms and systems and their limitations in realistically benchmarking in truly multi-agent settings.

8.2. Implications for Industry and Policy

Furthermore, under many circumstances the impact on traffic in recent years are becoming increasingly obvious although these do not generally impede traffic. Several cars on the road now already cooperate with each other by adjusting their speed in relation to each other so as to form platoons to save fuel [37]. Public opinions on our technologies may be somewhat opposed while the technology itself is basically neutral and focused on safety. On the other hand They also train truck drivers and work together with vehicle manufacturers in expanding the tests to American or European highways. Car companies and actually all other companies that are doing similar things are investing hundreds of millions of dollars in developing their own technology. The traffic is an ecosystem and influence and impact on current systems have to be taken into account when integrating the new AV technology within the system as well as making sure the technology enables efficient and fair delivery of transportation solutions to the user with respect to all these other stakeholders who will be influenced by the technology.

With the eventual deployment of AVs to public streets, demand for travel is likely to exceed what is currently observed, especially on existing infrastructure. As they can communicate with the infrastructure and with other vehicles, they can form platoons, merge, unmerge, and accelerate with reduced spacing. This reduces congestion and travel time. Therefore, more roads can be constructed for private vehicles operating in convoy mode. The resultant roadway will accommodate more vehicles, suffer less wear and tear and require fewer lanes and intersections including fewer parking spaces [38]. Overall this enables modern urban regions to retain more streets as green zones with less space earmarked for concrete and asphalt. But especially in the beginning, combinations of AVs, CAVs, and HVs will need to share the road and the challenges for AV R&D associated with these commercial vehicles are also discussed at length.

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