AI-Driven Approaches for Autonomous Vehicle Communication and Networking

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1. Introduction

In this New Era of the sixth generation (6G) of wireless technologies, the required incompatibilities and the desired solutions between connected and autonomous vehicles (CAV) with multidimensional security and resource management possibilities in the stretched vehicular communication infrastructure making full use of broader smarter world (robotic) mobile smart things due to multilayer interconnected (layer-less) collective intelligence, cellular internet node particularity, spatial groupiness, cognitive radio, block chain, AI/ML platforms are pivotal. Refinements of latent challenges specific lambdas for nanonetworking for a cluster of six Gs using block-hing based enroute computable, aggregation supported trust management with secure multistakeholder driven smart (SMS-Pki-LD) context evaluation with CATHEX multidonor-correlator are diversified innovative knowledge. More mature, simplified, intelligent and global 6G is needed to fit much more closely with the colourful requirements of a predominantly enroute automotives.Networking technology is inadequate to achieve the ambitious aims of Autonomous Vehicle, connected Autos and smart things in cellular internet domain in this sixth generation. Application driven services in this big data smart world (a group of seven Gs) demands for connectivity that are secure, reliable, flexible, bernoulli wit h Intelligence and massive mobility [1].

Autonomous Vehicle (AV) is a disruptive technology that is rapidly changing the norms of vehicular travel. Efforts made towards Intelligent Transport System (ITS) and Intelligent Vehicle/Cooperative Vehicular Networking were the hallmark of the past that laid the foundation of the future communication architecture. The performance of automobiles with infotainment, comfort, ecological performance, fuel consumption, cost effectiveness and security through cooperative mechanization like adaptive cruise controller (ACC), autonomous cruise controller (ACC), Lane departure warning (LDW), etc are directly linked with ITS in either vehicular networking domain [2]. Smart and proactive security and reliability management rationalized from the perspective of prospective 6G networking framework are the top priority of automotive trucks. Therefore, the future interdependencies of these future communication architectures proposed for connected vehicles and AVs altogether require an entirely new set of paradigms and communication architectures, for developing a highly extensive conductive-automotives paradigm, to get the lead to interconnected solid world.

1.1. Background and Significance of Autonomous Vehicle Communication

Pushing AI algorithms to make AVs smart means that they have their decentralized sensing and computing resources for perceiving the world around them. Such smart vehicles will smartly utilize cooperation among them as a prime capability to improve the safety and performance of traffic systems, espe- cially when infrastructure-based intelligent transportation systems are temporarily unavailable. In intelligent traffic systems, there are several technologies that make AVNET a reality, including 5G+, video/lidar/radar sensing, mapping technologies, and AI techniques, such as machine learning . In this chapter reputed AI experts share some cutting-edge research from their perspective to expose the general principles for enhancing global AV networking opportunities for facilitating safe and efficient collaboration among AVS, while the co-guest editor gives the possible upcoming grand traffic scenarios in which such smart AVs should be able to make fewer exigent decisions, meaning using respectively more automatic responses and alerting mechanisms that could get just specific instant assistances from VANET.

Autonomous vehicles (AVs) use AI algorithms for sensing the environment and planning their routes to their destinations [3]. Both sensing and planning processes need distributed communication systems for safe and efficient driving [1]. Future collaboration between AVs should leverage, in particular, the emerging vehicular ad-hoc network (VANET) technologies to exchange information about traffic conditions. This chapter presents an overview of cutting-edge research on enabling autonomous vehicles (AVs) to virtually communicate with each other and introduce the related computer system and networking architectures. It discusses what AI algorithms equip AVs with to exploit the potential of new vehicular networks for safe and efficient maneuvering around specific traffic scenarios.

2. Fundamentals of Autonomous Vehicle Communication

Consequently, in order to guarantee data transmission floors independent of the street traffic message, a fiber optic network (FON) is seen as the control domain. To provide an external-to-vehicle (E2V) communication with sustainable packet delivery within a certain time frame, a Car-to-Cloud (C2C) aggregation of data from the ecosphere-level routing is established and by the high bandwidth cloud, the accessibility of multimedia files like digital map update files and law recognition point clouds is ensured. In summary, information is sent to the vehicles using the CACC, TCACC, and other discussed functionalities from the Vehicle-to-Anything (V2X) working group for the next generation SAE J3161 working group's Edge Artificial Intelligence signal is the next step in this procedure. In particular, by providing a distribution with all the details, the CACC partner contributed to safety wellbeing the improved road traffic ecosystem considering all active and passive road users [4].

Control synthesis in the form of stochastic CACC was demonstrated with derived conditions that guaranteed string stability. Another study blended the traffic flow model with the protocol/data link layers and physical PHY/MAC players for a comprehensive evaluation. Although wireless technologies have shown promise for CV applications, they may not be practical for all applications especially in rural or less populated areas. Furthermore, to connect the majority of today's vehicles, the traffic flow and dynamics and implementations with well-established communication protocols have ranging HMI for specific applications including safety and environmental missions [5]. Therefore, with the private resources of the Internet, the current most viable technology would be the infrastructure-to-vehicle (I2V) communication as a V2I communication referred to in the remainder of the paper. To aid in joining the V2I and V2V approaches, this study provides the development of mesh networking that is dynamically created, Self-organizing Networks, in which network members bridge data between source and target.

Cooperative Adaptive Cruise Control (CACC) utilizes wireless communication among vehicles to gain awareness aiding in the development of algorithms for CACC. These physical models can then render the desired inter-vehicle spacing and added control mechanisms. The network ensures robustness by establishing an asynchronous decentralized system. For robustness in the presence of communication network uncertainty, it is essential for the vehicle to generate an optimal trajectory with AON [6]. Several CACC systems have been studied. For instance, a hybrid decentralized CACC controller was presented which controlled the spacing with a string of vehicles.

2.1. Wireless Communication Technologies for Autonomous Vehicles

For connected and automated vehicles, real-time seamless communication is indispensable for configuring the next generation of connected and automated vehicles, "intelligent" automatically driven vehicles and unmanned aerial vehicles. The basic intuitions are shared with cellular vehicles and can be seen as an abstraction of the connected and automated vehicle case. Proper scheduling of unmanned aerial vehicles and efficient management of its sensing and reporting capabilities makes this approach intuitive also in this new scenario, in which the generic abstract model vehicle will be replaced by the more detailed CAV. The infrastructure conversion process is inspired by the 4G-LTE approach exploited in cellular technology, but here is more abstraction and flexibility financial benefits make live implementation of such algorithms in large knowledge production beautiful future networks possible in the next 5 to 10 years. Traffic jams can be avoided and possibly in TRID the cars can bypass areas of the city that are too much congested due to an unusual event, also respecting other parameters like emissions to be within legal limits, or the necessity to pass from a certain place. [7].

Vehicular communication technologies are crucial for autonomous vehicles. Consequently, these devices need to be communication compliant and participatory, in the sense that they have to disseminate safety messages correctly, as well as be able to correctly interpret the same kind of messages coming from the environment. Classical implementation of the MAC does not take into account the autonomous decision-making of self-driving cars. The paper presented in [8] proposes a novel MAC scheme devised to take into account the different priorities of CVs and CAVs and allow a CV to precisely know the decisions taken by a CAV.

3. AI Applications in Autonomous Vehicle Communication

[9] Future autonomous vehicles will use Driving Intelligence Autonomous Vehicles (DIAG) to have their own sensitive sensory cells embedded in the data handling and intelligent means to interpret and interact with the surroundings. The normal vehicles feed driving experience into an AI algorithm, which naturally focuses on the mobility of the vehicle and does not include vehicle cooperation. Then also suitable communication signals from the vehicle control could provide a very valuable input for the discomfort analysis. The mid-term target

is the development of DIAG so that our future vehicles will have real-time instinctive knowledge of their ambiance represented by a multi-layer sophistimex structure. Ultimate vision of autonomous vehicles results in the minimal need of in- formation updating, so, it is also prepared to effectively settle at the traffic lights, if any. Our approach is able to associate unique driving experience data with the environment and finally it generates username or/and password that enable e.g., the continuous usage of properly adapted in-vehicle features, similarly as we describe it in for the environmental sounds identification and monitoring of home appliances in case of.[10] Highly automated driving (HAD) systems are expected to be launched in the market in the near future, addressing higher-level (SAE level 3 and above) vehicle-automation in which the entire driving task is performed by traffic and environmental conditions which may result in increased road safety, traffic efficiency, and vehicle mobility. In a recent study, it is reported that HAD and connected autonomous vehicles (CAVs) equipped with dynamic-path synthesis can significantly reduce the environmental impact if properly integrated with the traffic stream. However, to achieve the desired goals, beside HAD and the related communication systems, another primary requirement is to develop intelligent traffic light systems complemented with efficient real-time signalisation, smart power management, fully adaptive signalisation responsive to smart mobility and smart weather. These future intelligent traffic light systems are the focal point of driver-assistance systems and intelligent infrastructure. This paper introduces artificial intelligence (AI)-enabled traffic light system on-board technique to predict phase transition and detect priority-accident vehicles effectively in real time.

3.1. Machine Learning for Channel Estimation

ML has been recently exploited for this task within the context of high mobility communication to vehicular networks. The problem is quite new, and the principal challenges consist of achieving minimality of the feature spaces and of the dimensionality then managing side-information collected in high mobility communication. The channel estimation task at receiver side traditionally consists of detecting and estimating the Time Domain (TD) and the Frequency Domain (FD) spatial signatures of the transmitter (the multiple base station endpoints ability is taken into account by modalities such as practical antennas system scanning from MIMO to Massive MIMO and beamforming assemblies) allowing Multiple Access Interference (MAI) to be separated from the signal of interest [11]. These processes are achieved using hardware algorithms and by decoding.

The selection at the receiver side of communication systems which eliminates the interference from undesired sources and allows the extraction of the wanted information (channel estimation) traditionally was performed through decoding via spectrum sensing techniques. Machine learning (ML) radically changes this perspective, by exploiting the ex-post statistics of the radio channel to estimate it from scratch directly at the receiver [12]. In emergent intelligent systems, such as intelligent transportation systems (ITSs) and autonomous vehicles, channel estimation becomes a software function that relies on ML rather than hardware and analog filtering using carrier grids [13].

4. Challenges and Solutions in Autonomous Vehicle Communication

Regarding the timeframe-wisestudy of the driving data set, strategies need to be evolved to suitably cluster the driving styles in small sub-groups to model using probabilistic machine-learning algorithms and intelligent mathematical frameworks based on information and uncertainty theories, mainly at the outset of the task. Consequently, while improving the prediction accuracy, the computational complexity, communication overhead, and resource utilization are significantly reduced. The seamless integration of the learned/computed driving skills into a cloud-to-car edge communication enhance the safety and energy conservation and extend the real-time responsiveness of AI-based vehicle cooperation and traffic safety schemes [14].

Edge computing and intelligence capable of providing efficient and rapid data processing play a crucial role in the realization of a reliable and secure communication channel for autonomous vehicles, which is required for the realization of a secure and efficient communication network [15]. Together with edge computing, machine learning, deep learning, and artificial intelligence (AI) can enhance the capabilities of processing and intelligence of standalone, embedded devices providing extensive service capabilities [16]. The provision of trending and advanced vehicular services becomes possible through various AI-based solutions, including the provision of high-throughput deep-learning algorithms, low-latency intelligent entity cooperative service sets, efficient position-based routing, and energy-efficient solutions; this is in addition to different computer-based frameworks and algorithms for intelligent networking and communication.

4.1. Security and Privacy Concerns

Most of the vehicles in the future will communicate with each other through V2X, and this communication will be used in various ways, from non-critical messages such as some application information to lifetime-critical messages, including obstacle detection information in the vehicle's path. Communication requirements in V2X networks depend heavily on the richness of information provided about the physical world that only the human senses are currently somewhere. The autonomous driving system mainly triggered by the questions of security because of the studied nature of V2X protocols and the loss of importance when the trust between the elements in the post-factory were used also in support of the detection of the incoming cars. The Security Management Center that has been proposed among the main authorities in the sector oversees the endorsement of the belief of practical assessment policies and the disturbance of the panic content of a region known as the escape committee. When a secure communication environment can be provided, the network can allow new and technical applications that can make autonomous control networks very full. The most effective study on one layer is support for cooperative and local awareness and alertness with software. Since every event is reported in real time, it can be used for traffic flow optimization.SOEVER96%, instead of the traffic officer, proactive traffic management systems, which provide defects on the return path.GraphNode will direct and delay some nodes in the question area [17].

The primary communication protocol for future in-vehicle networks will be Automotive Ethernet, primarily for the sake of security. When new technologies like AI and V2X are introduced, they bring new security concerns to autonomous driving, especially considering the fact that it uses machine learning algorithms [18]. Let us assume that vehicles can be controlled in real time via cloud services in an autonomous driving world. In the initial state, the vehicle could receive an environmental data via acceleration / deceleration, location / track control, and basic data such as acceleration / braking from the car. If the link with the cloud system is applied by default, the incident reports and notifications destroyed all of these vehicles. Looking at another attack scenario, it determined that all the required devices could update their parameters. This can be seen as a manifestation of the cloud out of harmony, with various parameters violating the physical constraints of the autonomous driving system, the ability called obfuscation of the real world, and the universe to overcome decentralized states [19].

5. Future Directions and Emerging Technologies

AI play roles in intelligent communication management and diverse types described in the source article. Within this article, crucial AI-based cooperative strategies for diverse control tasks have been categorized into cooperative control categories, as follows: Cooperatively interacting vehicles, Cooperatively interacting roadside infrastructure, Total cooperative system. IBM Autonomous Driving Networks AI-driven closed-loop traffic adaptive optimization can increase fault handling from 3 nines to 5-6 nines. Autonomous Vehicles and Cooperative Driving: Next generation vehicles with Advanced Driver Assistance Systems (ADAS) and Automated Vehicles (AVs) are becoming an inseparable part of the mobility ecosystem in smart cities.In this article, the authors have offered the comprehensive study on the latest developments in autonomous beneficiary. Autonomous Driving and Cooperative Driving (ACD) in traffic congestion, heterogeneous traffic, and vehicle and path diversity have two main outcomes: increased safety of the passengers and managed travel time. Managed travel time can compensate for the delay and improve the profitability of carriers. For a proper cooperative driving, situational awareness is vital. AI transformation couldn't be stronger nowadays as the demand for IT is huge in various fields3(line 3)uring the whole design, deployment and operation phases of wireless networks. AI technologies, with key applications in network operation and optimization, are envisioned to play a major role in shaping the future of autonomous driving. AI has been applied to many studies and projects in vehicular communication and networking, but such research mainly explored the solutions for non-autonomous vehicles. The research on AIbased cooperative communication and networking in the context of autonomous vehicles, however, was very rarely reported. AI-based vehicular networks will surely disrupt the way vehicles are today, uncap, in particular aspiring to be autonomous. AI-based mechanisms are mainly open to explore cooperative driving, decision making, path choice, and secure traffic integration in smart cities. Along with it, advanced automotive networking also provides numerous avenues for investing AI technologies and fostering AI with endorsements of autonomous driving feature. Furthermore, big and smart data lead to innovation in mobility, traffic, and diverse autonomous vehicle cooperation. Smart contracts and AI-triggered cooperation is explored for Automated Driving.

[13]Recent advancements in vehicle communication and networking, including autonomous and connected vehicles have greatly improved traffic safety and driving automation. This

chapter has provided an overview of state of the art AI-based communication and networking approaches for autonomous vehicles. Underlying communication motivating use cases, challenges, enablers, and requirements of V2X communication were first reviewed with an emphasis on autonomous vehicle operation. Then, the possible solutions currently being implemented or under development were analyzed. Moreover, the limitations of autonomous V2X networking were highlighted, and possible AI-based mechanisms to mitigate them were outlined in addition to a discussion on the future research directions in the domain. To realize the cooperative autonomous vehicles of the future, AI-based cooperative driving is essential as explained in this article [20]. Key open challenges were also identified for future research, and it is revealed that there is scope for new AI-based cooperative driving mechanisms fitting specific driving use cases and AI-driven V2X data management. The article indicates that original contributions and recent research advances that bear the potential to profoundly impact the way the cooperative autonomous vehicles are secured in the future. The explosion of AI-based network management techniques and recent advancements in smart X have guaranteed profound impact on the way wireless networks are managed in the future in this article [21]. It is now believed that not only V2X communication management should be intelligent and context-aware to enable cooperative autonomous driving, it should also feature minimal human control.

5.1. 5G and Beyond for Autonomous Vehicles

However, in general, various types of communication networks, including local vehicular ad hoc networks (VANETs), cellular networks, public communication networks, WLANs, and sensors, are key in all these architectures. Each of these technologies has its own pros and cons relative to the other technologies. Long-range communication mainly uses cellular network capabilities for V2X (Vehicle to Everything) communications, mainly by focusing on recent advancements in the cellular communication technologies and associated 3GPP standards and research. This section concentrates on the role of future 5G communication systems and their evolution and their capabilities in supporting AVs. This includes an agreement on the fact that capacity and QoS of V2X communication can decisively increase overall AV performance in traffic scenarios, and that V2I communication are crucial to enable other future application scenarios [ref: 5: 9b0668b9-ef69-465d-8bc9-873d6be2e2bf].

A self-driving vehicle is an autonomous system that transports people or things without human operator intervention. Autonomous vehicles have been researched for several decades, but have only recently become commercially available. Key challenges in realizing self-driving vehicles include hardware and software technology for safe and reliable driving, an efficient sensing and computing architecture for real-time information processing, prediction of future driving conditions, communication, networking and security, privacy and ethical issues. A complete autonomous driving system also requires cloud-based traffic control centers to comprehend traffic and predict and control traffic flow [22].

6. Conclusion

In summary, various AI/Deep learning-based solutions for AV-Collaboration are reviewed. AI/Deep learning-based AV-CIS solutions seem to be the best among others due to the potential to handle both predictably and unpredictability induced communication demands. At the same time, various AI/Deep learning-based AV-CIS solutions are also having challenges such as dynamic environment handling and autonomous driving network (ADN) related options including AV-CIS might be another possibility to guarantee on-time privacy-aware and secure AV collaboration. Lately, AI-based approach to V2X communications will improve security-related options with respect to V2X communications.

[20] Autonomous de ives (AVs) are vital to solve the problems associated with conventional vehicles. Current AVs use a wide range of sensors to perceive surroundings including lidars, radars, cameras, Ultrasound, etc. The data produced by these sensors provide vital inputs to AVs. AVs drive conservatively and they can be fully trusted with respect to their driving behavior. However, when it comes to AV-to-AV and AV-to-Infrastructure communications, conventional AVs become different by solely relying on time-saving and unsynchronized state-based communication methods like dedicated short-range communications and/ or cellular vehicle to everything technologies. The problems associated with these methods in communication are well known including signal attenuation, interference, packet collision, communication overhead and latency. Nevertheless, AV-to-AV and/or AV-to-Infrastructure need to be treated cautiously with respect to their potential use regarding autonomous and semi-autonomous critical applications like collaborative driving because exploiting state-of-the-art tools such as AI/Deep Learning in communication and networking, emerging requirements of communication needs induced by AVs can be met by more efficient ways.

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