Top Level Newsletter: Connected Vehicle

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Vol 47: Contains articles on ADAS (Advanced Driver Assistance Systems) on …

1. ADAS: Past, present and future
2. The future of AI (Artificial Intelligence) in automotive systems
3. Toward High-Powered Connected Autonomous Vehicles: A Cooperative Solution via Transient Edge Intelligence Provision

General Notes

This series of newsletters is intended to provide the IEEE member with a top level briefing of the many different subjects relevant to the research, development and innovation of the connected vehicle.

The objective is to provide a platform for fast learning and quick overview so that the reader may be guided to the next levels of detail and gain insight into correlations between the entries to enable growth of the technology. Intended audiences are those that desire a quick introduction to the subject and who may wish to take it further and deepen their knowledge. This includes those in industry, academia or government and the public at large. Descriptions will include a range of flavors from technical detail to broad industry and administrative issues. A (soft) limit of 300 to 600 words is usually set for each entry, but not rigorously exercised.

As descriptions are not exhaustive, hyperlinks are occasionally provided to give the reader a first means of delving into the next level of detail. The reader is encouraged to develop a first level understanding of the topic in view. The emphasis is on brief, clear and contained text. There will be no diagrams in order to keep the publication concise and podcast - friendly. Related topics in the case of Connected Vehicle technology, such as 5G cellular and the Internet of Things will be included. The terms Connected Vehicle and Automated Driving will be used inter-changeably. Articles from other published sources than IEEE that add to the information value will occasionally be included.

This newsletter forms part of the regional Advanced Technology Initiative (ATI) of which connected vehicles form a constituent part. Technical articles solely from IEEE journals/magazines are referred to by their Digital Object Identifier (DOI) or corresponding https link. The link for each article is provided. Those readers who wish to delve further to the complete paper and have access to IEEE Explore (www.ieeexplore.ieee.org) may download complete articles of interest. Those who subscribe to the relevant IEEE society and receive the journal may already have physical or electronic copies. In case of difficulty please contact the editor at kaydas@mac.com. The objective is to provide top level guidance on the subject of interest. As this is a collection of summaries of already published articles and serves to further widen audiences for the benefit of each publication, no copyright issues are foreseen.

Readers are encouraged to develop their own onward sources of information, discover and draw inferences, join the dots, and further develop the technology. Entries in the newsletter are normally either editorials or summaries or abstracts of articles. Where a deepening of knowledge is desired, reading the full article is recommended.

Article 1. ADAS (Advanced Driver Assistance Systems): Past, present and future

(Published from vehicleservicepros.com (full article), full article,1 July 2019 ,by Tracy Martin

Excerpt: Featured in futuristic automotive advertising, ADAS is touted as cutting-edge technology. However, the concept has been around longer than most people realize.

ADAS, or advanced driver-assistance systems, is front-and-center in today's automotive technology and is the precursor to fully autonomous driving vehicles. Featured in futuristic automotive advertising, ADAS is touted as cutting-edge technology. However, the concept has been around longer than most people realize.

One of the oldest driver assist systems is automatic braking systems (ABS) that was developed for 1920s era aircraft. Having an airplane skidding uncontrollably after touching down on a runway was to be avoided and ABS braking systems help prevent accidents during landing of heavy airplanes and eventually jet aircraft. It wasn't until the 1970s that Robert Bosch patents, in joint development with Mercedes-Benz, that ABS was widely used on automobiles. Chrysler and the Bendix Corporation developed an ABS system called "Sure Brake" for the 1971 Chrysler Imperial. Ford had "Sure-Track" on Lincoln Continentals and General Motors marketed "Trackmaster," a rear-wheel-only system on Cadillac and the Oldsmobile Toronado. Nissan had an early electronic ABS system developed by Denso fitted to their Nissan President sedan in the 1970s. BMW even applied ABS technology to the K100 motorcycle in the 1980s.

Another driver assist technology was the load sensing proportioning valve used in the mid-1960s. Proportioning valves were installed on pickup trucks to minimize vehicle spin (swapping ends) during hard braking on wet roads. The load sensing valve was located in the hydraulic system for the rear brakes. A metal rod attached to the pickup bed and the valve provided a rough indication of how much weight the truck is caring during braking. It functions to control the brake fluid pressure from the master cylinder in response to vehicle load and prevents early locking of the rear wheels.
Since the 1950s speed warning systems have helped drivers to ease off the gas pedal to reduce speed. The 1962 Buick Wildcat's speedometer had a speed indicator that could be set by the driver. When that speed was exceeded a buzzer sounded as a warning to slow down. Other driver assists innovations include automotive cruise control that was new in 1947 but is common on vehicles today and the neutral safety switch (or inhibitor switch) for both automatic and manual transmissions—a form of driver assist that prevents drivers from starting the engine with the transmission in gear. Even some vintage radios had an automatic volume control that would increase volume with vehicle speed allowing the driver to pay attention to driving. All of these systems, while not labeled as true ADAS technology, provided early forms of driver assist functionality.

Current ADAS systems
Not everyone in the automotive industry uses the term "automatic assist"precisely, resulting in accidents caused by a misinformed driving public. This has happened with Tesla and other luxury cars when salespeople tout the benefits of their brand's offerings and over-state ADAS capabilities. For example, a salesperson might say to a customer, "Just press this button and the car almost drives itself." After purchasing the car the new owner gets on the Interstate, engages the ADAS system and starts playing a game on their phone. This lack of understanding of ADAS limitations has resulted in accidents with some fatalities.

Because OEMs, software companies and the aftermarket are all developing autonomous cars and the components that supports them, a common language is necessary to describe the technology to avoid confusion. In 2016 the National Highway Traffic Safety Administration (NHTSA) adopted descriptions of automated driving functionality, developed by the Society of Automotive Engineers (SAE) International, of five levels of ADAS technology. It's based on "Who Does What, When."

Level 0 - The human driver does everything.
Level 1 - Automated system(s) on the vehicle can sometimes assist the human driver to conduct some parts of driving tasks.
Level 2 - Automated system(s) on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving tasks.
Level 3 - Automated system(s) can both conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests.
Level 4 - Automated system(s) can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions.
Level 5 - The automated system can perform all driving tasks, under all conditions.
The use of ADAS that help drivers with steering, braking, monitoring and warning tasks is expected to increase over the next 10 years. In part this usage will be driven by consumer and government interest in safety applications that protect drivers and reduces accidents. For example, the United States and European Union are mandating that all vehicles be equipped with autonomous emergency braking systems and forward-collision warning systems by 2022. The increased usage of ADAS will have a significant impact on the auto repair industry as well. Even a simple job like replacing a windshield is complicated by the presence of ADAS sensors that need to be calibrated. Businesses like The Windscreen Company (www.thewindscreenco.co.uk), located in the United Kingdom are having to educate consumers regarding increased costs for windshield replacement. Consumer surveys show that the car-buying public is increasingly becoming more interested in ADAS applications that offer driver comfort and convenience, like blind spot monitoring and parking assist. The following are some highlights of ADAS in current use.

Adaptive cruise control (ACC) also known as dynamic cruise control, is considered a Level 1 ADAS technology. ACC systems can use radar, LIDAR (like those made by Ainstein(www.ainstein.ai) laser or camera based sensors to assist drivers in maintaining spacing between vehicles. Sensor input from ACC systems can use the vehicle's engine management system to control braking and acceleration at speed. Radar systems can be long, or short range and some vehicles use both. The black-box sensor on a laser-based system must be exposed to the area that it is tracking and because the laser reflects off other cars it does not work well (or at all) in heavy rain or snow. Some camera-based systems use two, forward-facing cameras placed on either side of the rear view mirror providing binocular vision to the system's computer. Through digital processing the ACC system can calculate distance of vehicles ahead.

On some vehicles collision avoidance is another feature of ACC systems and uses the same sensors to warn drivers of a potential fender bender, or worse. In addition to sensors, GPS information can be used to alert the system of fixed objects like stop signs, intersections, exit and entrance freeway ramps and other hazardous driving areas. Future ACC systems will have an impact on increasing the capacity of roads by maintaining optimal separation distances between vehicles and provide a safer driving environment.

Wake up! Anti-sleep pilot, driver condition monitor, fatigue detection or tiredness detection warning are some of the names of systems that warn a driver that they are not paying attention to the road ahead—time to get some coffee or pull over and take a nap. Studies have shown that 20 percent, or higher or road accidents are driver fatigue-related. Driver drowsiness detection and lane departure warning systems are similar, if not identical. They can use road lane monitoring via a camera, steering pattern monitoring or driver eye and face monitoring to determine when to sound a warning. Future systems could use body sensors to measure things like heart rate, brain and muscle activity and skin conductance as a measure of how awake a driver really is.

From the inception of the automobile the ability of a driver to "park" the car has been a challenge. The parallel parking test for licensing is one of the most difficult skills that drivers have to demonstrate—so difficult that 16 states have dropped the requirement. The lack of parking skills has led to a vicarious form of entertainment—watching drivers trying to parallel park. No matter how many times they back-and-fill, and/or bump other cars, they can't seem to get any closer to the curb. Automatic parking is an ADAS system that bridges the gap between driver assist and fully automatic driving in that the system takes over steering during parking maneuvers.

In general, Automatic Parking Systems (APS) use ultrasonic sensors located at the four corners of a vehicle to determine its position relative to other parked cars. In operation APS is turned on and the car is driven past the desired parking spot to determine if there is enough room to park. During parking the system instructs the driver to put the car in reverse or drive and apply the brakes until the car is parked. Perpendicular parking is a similar process. After driving past an empty parking space and measuring it, the vehicle self-steers, backing into the space while the driver controls the gas and brake pedals. With driver angst over parking it's no surprise that automakers want to offer customers a way to circumvent their lack of parking skills.

Future ADAS systems will be a real factor in differentiating automotive brands from one another. OEMs and their suppliers know that they will also be a significant revenue source for selling consumers various levels of trim and add-on packages. As costs for ADAS tech comes down it will be found on less expensive cars and become common place.

ADAS and autonomous cars

As evidenced by current ADAS systems, driver assist technology of the future is only going to become a larger part of consumers' automotive experience. The use of ultrasonic, radar and optical sensors will provide a more complete picture of a vehicle's surroundings and shift more driving responsibility away from human drivers and towards computers with the goal of a safer and more relaxed driving experience. An important part of the transition to fully automatic driving is connecting vehicles to one another and their environment. The combination of sensor technology and connected vehicles will play an increasingly import role in the transition from ADAS systems to fully autonomous vehicles.

While ADAS systems are effective for line-of-sight driving situations they can't offer the situational awareness of vehicles that are connected to one another and the environment. Vehicles that are connected to each other can use their respective sensors to create a network of awareness that will extend far beyond the range of a single vehicle using ADAS alone. Connected vehicles will receive alerts of dangerous situations providing drivers and autonomous vehicles more time to react. For example, an oncoming car in the wrong lane in a blind curve; vehicles swerving to avoid a road obstruction; a driver about to run a red light as they are nearing an intersection could all be detected by connected cars that would transmit this information to other vehicles.

Connected vehicle technology will ultimately be less expensive to install per vehicle than ADAS systems and perform many, if not all the same functions. Connected cars will receive data from surrounding vehicles, and infrastructure, display driver alerts and interact with on-board braking, steering and engine management systems. OEMs, and high-tech players like Google and Microsoft are spending huge sums of money on research and development to create self-driving cars but they can't get there without ADAS systems that will bridge the gap between current driver assist features and fully autonomous cars. Within 10 to 20 years, drivers will be able to get into their car and say "Take me home." and read a book, or take a nap during the drive, but this will only happen in part because of ADAS systems that are used in today's vehicles.

Article 2. The future of AI in automotive, (by Kacey Frederick)

(Published from vehicleservicepros.com , (full article)17 November 2023)

As discussions arise surrounding the use of artificial intelligence (AI) in different work fields, the question remains of what that could look like in the automotive industry.

An AAPEX webinar, led by Predii Founder, CEO Tilak Kasturi and Vice President of Sales and Business Development Mark Seng, dives straight into how it can be best used and what its introduction into the industry will look like.

How can AI be used in the automotive field?

Seng points out that while many people use AI in their day-to-day lives, the way it functions in the automotive industry will *look a little different*. Similar to how AI is meant to mimic a human, AI for the auto industry would be built to function as a service advisor. Seng uses the example of a driver telling an AI system that he is unable to call someone on the phone while driving. An AI system specialized in automotive issues could pick up on the phrases “call” and “driving” and suggest a Bluetooth error. Even though shops that have been in operation for a few years have likely seen a multitude of different problems and scenarios come through their doors, every diagnosis and solution is not remembered by technicians.

AI can be used to leverage historical data from past repair orders and can even be used to help bring inexperienced technicians up to speed with new kinds of jobs. As vehicles become more complex, AI can be a useful tool to train new staff.

Shops frequently experience customers who are inclined to put off maintenance. If a customer agrees to share TeleDiagnostic data with the shop, the shop can provide a more accurate picture of the state their vehicle is in and will have personalized data from the vehicle itself when it’s time to perform maintenance. In such a case, it could be possible for a driver to be unaware of a potential issue with their vehicle while the AI picks up diagnostic codes that communicate problems to a shop before any warning lights appear on the vehicle’s dashboard.

While consumers are often concerned about having extra work performed on their vehicles, a shop being able to provide data on the issue can help the customer feel more confident in their choice. It also helps a shop prepare itself before the problem becomes worse. If an issue is detected and communicated to the shop through AI, any parts or supplies needed can be ordered before the customer even walks into the store.

How does it work, and how will it unfold?

Kasturi opens his presentation by explaining generative AI as an AI system that can generate original content based on data and that improves as it gains feedback and responses.

While generative AI has been able to demonstrate success in the lack of sufficient data, inaccurate, contradictory, and sometimes flatly false responses can also be generated. This can be useful for tasks such as creating images or audio, but in a technical field like automotive repair, precautions must be taken to avoid this.

The type of AI in the automotive industry would be able to intelligently answer and respond to questions through the simultaneous use of different data and sources of knowledge that would be applied to a specific make and model of a vehicle.

Though the use of AI in the auto industry has been studied for years, programs such as ChatGPT have only been around for a little under a year, and it's a technology that is steadily evolving. As it unfolds in the auto industry specifically, it will likely take place through four stages.

The first stage involves AI being introduced to an organization, mainly in applicable workflow tasks.

The second stage looks at the short-term implementation of AI, which will have trials of organizations experimenting with different AI systems to find one that will keep the questions received and answers generated by the organization's system safe and secure.

In the mid-term, organizations and businesses can gather enough data from AI that can be used to improve workflows and applications, and for an organization to even create its own generative AI. Long-term, automotive AI will be brought to the consumer, providing personalized data and services unique to them and their vehicle's needs.

However, for AI to be used in the industry to its full capabilities, regulations and standards are essential. Industry leaders such as the Auto Care Association and the Automotive Service Association have become involved in discussions surrounding AI's use in the field for precisely this reason.

The path toward AI being used in the auto industry is undoubtedly still a long one. But with it already being used in many segments, such as AI-generated estimates for collision repair, it may be in a business's best interest to learn how to leverage it for their work.

Article 3. Toward High-Powered Connected Autonomous Vehicles: A Cooperative Solution via Transient Edge Intelligence Provision (by Yu Liu et al)

(Published in IEEE Communications Magazine vol 61 Issue 12, December 2023, pages 94-100)

Abstract:
High-powered connected autonomous vehicles (CAVs) with excellent situational awareness are expected to achieve fully autonomous driving. With the increase of complex CAV applications, it is necessary to introduce an effective cooperation mechanism among differentiated edge nodes to provide a complete set of closed-loop control for sophisticated computing tasks. However, when leveraging edge intelligence (EI) for CAVs, neural networks are vulnerable to transient invalidation of edge nodes or transmission links, which may result in serious decision faults. In this article, we first summarize and analyze three situations that trigger transient changes in edge resources, that is, the invalid node, the departure node, and the bottleneck node. To tackle these problems, we propose a novel framework of robust intelligent edge computing orchestrator (RIECO) for CAV networks, which can maintain effectiveness in topology identification and closed-loop control. Importantly, to quickly recover from transient phenomena, the emergency plane proactively migrates defunct models to new nodes. To prove the feasibility of the proposed RIECO framework, we take a series of simulation experiences for different transient scenarios. Finally, some open challenges and future research directions are discussed.

Introduction

Toward the intelligent information society of 2030, both academia and industry focus their attention on the research of the sixth-generation (6G) network. Fully autonomous driving as a typical scenario of 6G aims to completely free people from driving and provide excellent driving experiences. During the last decades, autonomous vehicles can only realize Level 1 to Level 3 automation as defined by the Society of Automotive Engineers International. In addition, extreme weather or complex road conditions will cause a sharp drop in perceptive accuracy, which seriously threats driving safety. To compensate for intrinsic deficiencies of onboard sensors, V2X (vehicle-to-everything) communication equipment is added to autonomous vehicles. With the aid of V2X radio technology, connected autonomous vehicles (CAVs) are able to “see” and “talk” to non-line-of-sight objects in real-time. Despite the advancements in gathering environmental information, they are accompanied by data explosion.

It is predicted that each CAV will generate data of approximately 2 GB a second to achieve advanced self-driving applications (i.e., vehicle platooning and extended sensors). Although onboard computing and storage capabilities are growing rapidly, they are still insufficient to process these data. To enable delay-critical and computation-intensive applications at resource-constrained devices, high-powered CAVs introduce edge computing to assist data processing on the basis of traditional CAVs. Taking advantage of edge computing's context awareness, low latency, and so on, high-powered CAVs make advanced self-driving applications not previously achievable with traditional cloud possible. However, edge computing is not merely a straightforward offloading position shift. Instead, it raises several unique challenges.

To provide lower response delay, edge nodes equipped with certain numbers of computing units and storage units communicate with vehicles within their coverage via radio access points, such as the next-generation NodeB (gNB), evolved NodeB (eNB), and roadside unit (RSU). With the increase of complex applications, an edge node with limited resource capacity and coverage ranges is unable to provide continuous and consistent services for moving high-powered CAVs. Thus, it is necessary to introduce a cooperation mechanism among edge nodes to provide a complete set of closed-loop control for sophisticated computing tasks. Taking the task (i.e., lane changing, overtaking, and on-road accident early alarm) that requires low-latency training and learning from the deep neural network (DNN) as an example, the control information involves task partitioning and dispatching, transmission path selection, and so on. By empowering edge nodes with the powerful ability of data collection, processing, and analysis, flexible network management can be locally performed with edge intelligence (EI) techniques.

Nevertheless, neural networks are vulnerable to various transient invalidation issues, which can result in the deterioration of properties or even complete failure of EI techniques. As far as we know, there are at least three situations that trigger transient changes in edge nodes.

(a) Invalid Node: It is likely caused by internal factors (i.e., hardware failure and performance short-falls) and external factors (i.e., ownership alteration and resource preemption). Because there are frequent data transmissions between cooperative edge nodes, the transient revocation of any node can result in the failure of model inference.

(b) Departure Node: When the vehicle moves to the coverage of the other access point, it cannot continue to enjoy the services provided by the original node. In order to ensure service continuity, it needs to forward uploaded data to the new node of service deployment. A departure node introduces extra latency of data forwarding.

(c) Bottleneck Node: A certain edge node suffering from link congestion becomes the bottleneck node in distributed edge networks. High queuing delay will lead to degradation of inference performance. Furthermore, the transient break of partial transmission paths can also cause a bottleneck node.

For the problem that transient EI techniques are hard to be steadily used in CAVs, a novel framework of robust intelligent edge computing orchestrator (RIECO) for CAV networks is proposed in this article,

Edge Computing for CAV Networks

Existing Frameworks: Since the first white paper published by the European Telecommunications Standards Institute (ETSI) in September 2014, many researchers have proposed their design schemes about using edge computing for supporting vehicular applications. The existing edge computing frameworks for resource management and task scheduling have been overviewed. From the aspect of the cooperative method, these frameworks can be broadly the three-layer framework with the terminal user at tier one, edge nodes at tier two, and remote cloud servers at tier three. Through full consideration of the computing, communication, and storage capabilities of the equipment in different tiers, various service requirements can be satisfied with the cloud-edge-end collaboration.

However, with the emergence of delay-critical and computation-intensive CAV applications, edge nodes must process tremendous data and return high-accuracy results to vehicles within milliseconds. When all high-powered CAVs offload their tasks to the same edge node, the gain of edge computing significantly degrades due to heavy load and congested queue. Meanwhile, considering the high dynamics of vehicles, one edge node with limited coverage is incapable to provide continuous and consistent services for them. Thus, it is necessary to explore horizontal collaboration among various edge nodes, especially in CAV networks with massive CAVs, access points, and communication links. Up to now, the design of the orchestration framework for edge-edge collaboration in CAV networks still faces several critical challenges.

……………..…….(the next section from article has been abridged for brevity)……………..

Threats to Driving Safety

It is worth noting that transient service interruption will seriously threaten the safety of the operator, pedestrians, or other motorists in the fully autonomous driving scenario. However, the edge-edge collaboration makes the horizontal framework vulnerable to the failure of edges or links. Therefore, in order to enhance system robustness, more research is required to detect any possible danger and rapidly recover from the failure.

Open Issues:

1. Security and Privacy: To provide continuous and consistent V2X services for high-powered CAVs, frequent information interaction is required among cooperative edge nodes. Directly sharing original data has a risk of privacy leakage and data breaches. Conventional guard methods of cloud computing cannot reach the security standards for edge computing, especially in transient edge networks. Furthermore, authentication at heterogeneous edge nodes may further increase the difficulty of privacy protection. Accordingly, a fine-grained, flexible, and decentralized security mechanism for edge networks is required.

2. Green Edge Computing: With the rapid growth of vehicles, more and more edge nodes are densely deployed in networks. To ensure the operation of these electronic devices, energy-efficient measures need to be adopted. Unluckily, traditional energy conservation technologies are readily inapplicable. For example, due to the intermittent and randomness of renewable energy, edge nodes cannot obtain sustained energy. It brings fatal hidden danger to vehicular networks. Furthermore, energy management becomes more complex owing to the complex and time-variant network environment. As a result, how to design a green edge computing system is to be solved.

3. Digital Twin Networks: Considering the fatal impact of wrong decisions, it is necessary to build a simulation environment to test the performance of the proposed schemes before applying them to real physical networks. Digital Twin (DT) by building emulated software replicas of CAV networks enables orchestrators to perform testing, predict incidents, and update networks. However, different from conventional test solutions, DT faces a series of unique issues and challenges to be addressed, including network visualization, interface standardization, and so on. Due to the high complexity of edge networks, these are still not in consensus and further research is needed.

Conclusion

In this article, we propose a RIECO framework for CAV networks to enable delay-critical and computation-intensive CAY applications. Through collaboration among the awareness plane, the control plane, and the emergency plane, the framework is capable of effectively providing a complete set of closed-loop control for complex computing tasks. In addition, to enable neural networks to adapt to the floating network environment, we make improvements to existing DL/DRL algorithms. Simulation results further demonstrated that the proposed RIECO framework can keep good performance even if transient instability of edge nodes or transmission paths occurs. Finally, further research directions are pointed out. This article has opened a window for the innovations of high-powered CAVs in transient edge networks. Although there are still many challenges to the implementation of RIECO, the collaborative mechanism among edge nodes and closed-loop control for sophisticated computing tasks are the fundamental problems to be solved. In summary, the RIECO framework laid a solid foundation and owns a wide application prospect for future high-level autonomous driving

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