Top Level Newsletter: Connected Vehicle

(Published by IEEE Orange County Section)

May 2022
Volume 29.0

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Systems Research Development and Innovation

Vol 29: This issue takes a peek at deep neural networks as applied to autonomous driving systems and another peek at Electric and Hybrid Electric Vehicles following on from a previous article in Vol 25 of the Newsletter:

(1) Deep Neural Network Perception Models and Robust Autonomous Driving Systems: Practical Solutions for Mitigation and Improvement

(2) State of the Art and Trends in Electric and Hybrid Electric Vehicles

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.

1. Deep Neural Network Perception Models and Robust Autonomous Driving Systems: Practical Solutions for Mitigation and Improvement

Mohammad Javad Shafiee et al

Published: IEEE Signal Processing magazine (Vol 13, Issue 4, Winter 2021, pp22 - 30)

The National Highway Traffic Safety Administration reported that more than 90% of in-road accidents in 2015 occurred purely because of drivers' errors and misjudgments, with such factors as fatigue and other sorts of distractions being the main cause of these accidents

One promising solution for reducing (or even resolving) such human errors is via autonomous or computer-assisted driving systems. Autonomous vehicles (AVs) are currently being designed with the aim of reducing fatalities in accidents by being insusceptible to typical driver errors. Moreover, in addition to improved safety, autonomous systems offer many other potential benefits to society: 1) improved fuel efficiency beyond that of human driving, making driving more cost beneficial and environmentally friendly, 2) reduced commute times due to improved driving behaviors and coordination among AVs, and 3) a better driving experience for individuals with disabilities, to name a few.

The limited autonomous driving capabilities of current AV systems are due to a range of challenges, such as the high cost of sensors, a lack of acceptance by the public, a lack of appropriate safety evaluations, and the high error rates of existing technologies.

The general architecture of an autonomous driving system is composed of the two main components of (a) perception and (b) decision making. The perception system typically consists of a set of machine learning algorithms and provides a semantic understanding of the world around the vehicle. The perception system can be negatively affected by different types of intrusion algorithms, commonly referred to as *adversarial attacks*. The perception system (and especially the sensing the world module) is the first step between the outside world and the autonomous driving system; therefore, any incorrect conclusions from the perception system, due to adversarial attacks, will propagate to later components, leading to potentially fatal decisions being made. The decision-making component of an AV is composed of motion planning, decision making, and control. These modules are responsible to identify the best path for the vehicle and to actuate the car toward that.

Given the mapping of the environment and the AV's current state, the decision system makes decisions on what actions to be taken to optimally reach a goal; that is, the system is responsible for generating route proposals, motion planning for each of those routes, evaluating compliance with passenger preferences and the law, calculating safety probabilities of each proposed trajectory, and making decisions on which trajectory to select. The control system acts upon these decisions and controls the vehicle, generating appropriate commands and ensuring that the proposed trajectory is followed. There remain several challenges regarding the interaction of these two parts. In particular, the decision-control system should reevaluate the possible risks in different situations constantly and predict the intentions of human drivers around the vehicle. Effectively estimating uncertainty is very important; however, understanding human driver intention is still not a common practice in the field and is usually relaxed in the problem formulation.

Conclusions: Autonomous driving offers potentially major advantages to society, such as reducing injury and gasoline usage while also decreasing insurance costs. The past few years have witnessed remarkably significant progress toward fully automated vehicles being present on public roads. However, there do still remain concerns regarding the reliability of the computer vision and data analysis models operating within AVs and, even more significantly, their robustness in different situations. In this article, we examined the robustness of autonomous systems, focusing on proper functioning in adverse conditions/environments and in the presence of intrusions and adversarial attacks. Practical solutions to mitigate these issues and to improve the robustness of these models were discussed, ranging from extending data sets by simulated data, simulated evaluation environments to uncover corner cases, and new techniques to better calculate the uncertainty of such models in decision making, all strategies that can help to improve the performance of models in real-world applications.

The tremendous success of autonomous driving has opened a vast range of opportunities for researchers across a wide range of domains but also for members of society beginning to imagine a different future. This excitement has led to raised expectations and optimistic timelines about how soon such vehicles might be expected; however, for reasons of safety and engineering ethics, it is essential to fully understand the robustness and reliability of the designed systems. (565 words)

DOI: https://doi.org/10.1109/MSP.2020.2982820

2. State of the Art and Trends in Electric and Hybrid Electric Vehicles

(Mehrdad Ehsani et al)

Published: Procedings of the IEEE ((Vol 109, Issue 6, June 2021, pp 967 - 984)

Abstract: Electric and hybrid electric vehicles (EV/HEV) are promising solutions for fossil fuel conservation and pollution reduction for a safe environment and sustainable transportation. The design of these energy-efficient powertrains requires optimization of components, systems, and controls. Controls entail battery management, fuel consumption, driver performance demand emissions, and management strategy. The hardware optimization entails powertrain architecture, transmission type, power electronic converters, and energy storage systems. In this overview, all these factors are addressed and reviewed. Major challenges and future technologies for EV/HEV are also discussed. Published suggestions and recommendations are surveyed and evaluated. The outcomes of detailed studies are presented in tabular form to compare the strengths and weaknesses of various methods. Furthermore, issues in the current research are discussed, and suggestions toward further advancement of the technology are offered. This article analyzes current research and suggests challenges and scope of future research in EV/HEV and can serve as a reference for those working in this field.

Introduction: Hazardous emissions and greenhouse gases (GHGs) are the side products of the combustion of fossil fuels for energy needs. The emission of GHG is the major cause of rapid climate change, such as global warming and the melting of polar ice. The GHGs mainly comprise CO_2, NO_x, CO, and methane. The emission of GHG from various transportation sectors is 14% (electricity and heat production 25%, agriculture and forest 24%, industrial 21% etc). Worldwide development and expansion of numerous urban areas have substantially increased the number of vehicles on the road. Of course, this high percentage of transportation GHG is due to the vehicle's internal combustion engine (ICE). Therefore, the decarburization of transportation will eliminate the CO_2 emissions of the transportation sector. This has motivated modern efforts to replace ICE-based vehicles with alternative power plants that are sustainable and clean. Thus, electric vehicles (EVs) have been viewed as a substitute for ICE vehicles. The EV offers the possibility of zero vehicle emissions, lower lifetime cost, enhanced safety, and possible renewable energy. However, the present EV technology is associated with the problems of limited range, high initial cost, and longer recharge time compared with the ICE vehicles. The limited range of EVs may not pose a problem in many metropolitan areas and developing countries. However, the present lack of necessary fast-charging stations poses a barrier to entry even in these suitable areas. One alternative for overcoming the disadvantages of EVs is hybrid EVs (HEVs). The HEV technology can be developed to overcome the aforementioned shortcomings of both ICE vehicles and EVs. The HEV combines the ICE with a battery-powered electric motor (EM), combining the advantages of both for transportation. These include low emissions, high reliability, high fuel efficiency, and long range compared with the ICE or EVs.

Furthermore, the HEV can still recover the braking vehicle kinetic energy, as in the EV. However, the HEV powertrain is more complex compared to the EV or the ICE vehicle. This complexity stems from its components and controls. This article presents an overview of the important components utilized in the HEV powertrain, as well as their architectures, energy management strategies (EMSs), choice of power electronic converters, hybrid energy storage systems (HESSs), and traction motors.

Conclusion: This review offered an overview of powertrains for the different types of EVs.

The fuel economy, drivability, and emissions are the main motivations for going to modern EV and HEV technologies. The HEV powertrain is more complex, in its architecture and control than the conventional and EV powertrains. This is mainly due to their two or more power sources, requiring optimal dynamic power split among them to achieve the best fuel economy. Power electronics, traction motors, and energy storage and recovery systems are the core technologies of EV and HEV powertrains. Hybridization of the ESSs divides the requirements of high energy density and high power density among two or more storage technologies, resulting in higher vehicle performance, longer range, and better fuel economies. Vigorous research and development, in the above areas, are being conducted in academic and industrial labs, internationally. The ultimate objective is to produce vehicle products that are preferable to conventional ICE vehicles in the marketplace. This will result in a natural transition to better automobiles and a healthier environment. (700 words)

DOI: https://doi.org/10.1109/JPROC.2021.3072788