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Autonomous Driving: Part 2—Learning and Cognition

This special issue covering autonomous driving is presented in two parts: Part 1—Sensing and Perception was published in the July 2020 issue of *IEEE Signal Processing Magazine* (*SPM*) [1], and this issue, Part 2—Learning and Cognition. Learning and cognition models and, in particular, deep learning-based models are at the core of autonomous vehicles and automated driving. Autonomous driving and, more generally, automated driving are receiving increasing attention, and significant resources are being deployed to enable safe, reliable, and efficient automated mobility in real-world environments. Some of the needed enabling technologies include affordable sensing platforms, reliable simultaneous localization and mapping, machine learning that can effectively handle varying conditions and unforeseen events, "machine learning-friendly" signal processing, hardware and software co-design for efficient real-time performance, robust platforms that can withstand adversarial attacks and failures, and frameworks that can enable effective testing of emerging autonomous driving advances.

In this issue

The aim of this special issue is to provide researchers and professionals with tutorial-style articles covering the state of the art as well as emerging trends in the development and deployment of learning and cognition technologies for autonomous and automated driving. In particular, deep neural networks have been widely adopted and integrated as part of these technologies. Part 2 describes key concepts and the latest advances underlying the operation of such learning and cognition approaches. It also sheds light on remaining challenges that need to be addressed to enable reliable and safe operation in autonomous driving.

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Overview

This issue contains eight articles. Four of them deal with the robustness of learning and perception models under adverse conditions and/or adversarial attacks. The others cover various aspects of learning and cognition for autonomous driving. The first article, "Deep Neural Network Perception Models and Robust Autonomous Driving Systems," by Shafiee et al., is concerned with perception models and robustness in autonomous driving, with a focus on adversarial attacks. In "Self-Supervised Learning for Autonomous Vehicles Perception," Chiaroni et al. address self-supervised learning and the applications that the technology enables for autonomous driving. "The Vulnerability of Semantic Segmentation Networks to Adversarial Attacks in Autonomous Driving," by Bär et al., discusses the susceptibility of convolutional neural networks (CNNs) to adversarial attacks when these CNNs are deployed for semantic segmentation in the context of autonomous driving. The authors also review existing adversarial defense strategies. The fourth article, "Object Detection Under Rainy Conditions for Autonomous Vehicles," by Hnewa and Radha, is concerned with autonomous driving under adverse weather conditions, with a focus on rainy conditions. The authors review object detection methods that are being considered for integration into autonomous vehicles. They also survey and discuss state-of-the-art methods for mitigating the effect of rain on autonomous driving.

The fifth article, "3D Point Cloud Processing and Learning for Autonomous Driving," by Chen et al., summarizes cutting-edge processing and learning methods for 3D point clouds and offers perspectives on open issues that remain to be solved. "Deep Inverse Reinforcement Learning for Behavior Prediction in Autonomous Driving," by Fernando et al., is concerned with behavior modeling in autonomous driving, with a focus on deep inverse reinforcement learning. In "Novel Arithmetic in Deep Neural Network Signal Processing for Autonomous Driving," Cococcioni et al. review current and emerging arithmetic for deep neural network (DNN) signal processing. The authors also highlight the issues in implementing DNN accelerators to achieve low-complexity processing of automotive sensor signals without compromising

accuracy. Deter et al. close the issue with "Simulating the Autonomous Future," which provides an overview of simulation tools for scene and scenario creation and describes open autonomous vehicle data sets, with a focus on constructing and validating virtual vehicle environments to replicate a range of test scenarios for autonomous driving.

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Reference

[1] L. J. Karam, J. Katupitiya, V. Milanes, I. Pitas, and J. Ye, "Autonomous driving: Part 1-Sensing and perception [From the Guest Editors]," *IEEE Signal Process. Mag.*, vol. 37, no. 4, pp. 11–13, July 2020. doi: 10.1109/MSP.2020.2990330.

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