Guest Editorial
Special Issue on Adaptive Learning and Control for Autonomous Vehicles

RECENT developments in the field of neural networks, adaptive learning, and control will enable autonomous vehicles to operate in complex environments including urban, rural, and dangerous environments.

With the rapid development of autonomous vehicles, such as ground, surface, underwater systems, incremental challenges in decision making, path following, collision avoidance, state estimation, and trajectory tracking, are expected to be tackled using adaptive learning-based methods. Moreover, the utility of autonomous vehicles critically depends on the level of autonomy. In this context, it is strongly worth developing autonomous vehicles to work in any unstructured or unpredictable environment without human intervention. Meanwhile, in the presence of complex unknowns including uncertainties, variations, and disturbances, adaptive learning and control (ALC)-based methods for autonomous vehicles are still desirable to be comprehensively understood, and thereby contributing to the advanced ALC mechanisms. This Special Issue features the most recent developments and the state-of-the-art ALC methodologies for autonomous vehicles. The Special Issue aims to provide a platform for sharing recent results and team experience in adaptive learning and control for autonomous vehicles. Emerging applications of ALC methods combined with deep learning, artificial intelligence, classical machine learning and control techniques, data fusion, communication technologies, and environment understanding/modeling are covered in this Special Issue. New methods are proposed for visual navigation, pose prediction, fault-tolerant adaptive learning control, adaptive resilient control, transfer learning management, adaptive iterative learning control, multi-object tracking and segmentation, distributed path following, and decentralized adaptive optimal tracking control for autonomous vehicles. The targeted audience includes both academic researchers and industrial practitioners.

Specifically, articles in the Special Issue cover the following research areas.

1) Adaptive Learning-Based Modeling, Optimization, and Control for Autonomous Vehicles: Qui *et al.* present a gradient descent-based ALC method for underwater systems. Wang *et al.* describe a collaborative neurodynamic optimization algorithm using discrete Hopfield networks for multivehicle task assignment problems. The article by Jiang *et al.* describes an ensemble learning method for semi-supervised vehicle type classification. Zhou *et al.* describe an adaptive learning network for real-time power management of hybrid vehicles. The article by Li *et al.* also covers the energy management subject from the point of view of platoon control. Articles covering the area of adaptive learning-based location and navigation of autonomous vehicles include Gao *et al.*, Han *et al.*, and Zhang *et al.* Gao *et al.* introduce a multitask learning-based real-time multiobject tracking method. Han *et al.* present a distributed path following multiple under-actuated autonomous surface vehicles. Zhang *et al.* present a visual navigation and landing control method on a moving autonomous vehicle. Zhang *et al.* introduce a consensus tracking method for heterogeneous multivehicle systems using iterative learning control (ILC). Cao *et al.* describe a weak human preference supervision method for deep reinforcement learning. The method can be used in robot locomotion. Huang *et al.* describe a deductive reinforcement learning method for visual autonomous urban driving navigation. They introduce a deduction reasoner (DR) to endow the agent with the ability to foresee the future and to promote policy learning.
2) Deep Learning-Based Methods for Autonomous Vehicles: A significant number of authors use deep neural network-based methods. For example, Tang *et al.* present generative adversarial networks (GANs)-based methods for semantic segmentation, depth, and pose estimation. Liu *et al.* present a neural network-based control algorithm for nonlinear systems with multiple objective constraints. Song *et al.* describe a tracking control method of unknown and constrained nonlinear systems via neural networks using activation learning. The subject of deep-reinforcement learning control of autonomous vehicles is covered by a number of authors. The article by Zhang *et al.* discusses safe reinforcement learning methods for stable motion planning. Li *et al.* describe a reinforcement learning-based vehicle platoon control strategy with the goal of reducing energy consumption. Wang *et al.* introduce a data-driven control method for unmanned surface vehicles (USVs). The article by Hu *et al.* describes a USV formation and path control method using deep reinforcement learning. Chen *et al.* present a neural Kalman dynamical model for motion estimation and prediction for autonomous vehicles. Zong *et al.* use graph theory and neural networks to

Digital Object Identifier 10.1109/TNNLS.2021.3123833

develop a decentralized adaptive neuro-output feedback saturated controller for autonomous underwater vehicles (AUVs).

3) Adaptive Resiliency, Fault Monitoring, and Supervisory Control of Autonomous Vehicles in Autonomous Vehicles: Zhang *et al.* describe an adaptive resilient event-triggered control system design for autonomous vehicles. Another related article is by Huang *et al.*, who present an adaptive learning control method for multiple autonomous vehicles under actuator faults. Zhang *et al.* present adaptive decision-making for AVs in roundabouts and they use reinforcement learning. Yu *et al.* present a fractional-order adaptive fault-tolerant synchronization tracking control method for networked fixed-wing unmanned aerial vehicles (UAVs) against actuator-sensor faults using the intelligent learning mechanism. Zhang *et al.* describe an adaptive learning model predictive control (ALMPC) scheme for the trajectory tracking of perturbed autonomous ground vehicles (AGVs) subject to input constraints. The authors use the recursive least squares (RLS) technique together with a suitable robustness constraint.

In addition to articles presenting ALC system application for land vehicles articles by Xu *et al.*, Fang *et al.*, Zong *et al.*, and Qiu *et al.* describe applications of ALC systems in underwater autonomous systems. Articles by Wang *et al.* and Wang *et al.* describe ALC methods for unmanned autonomous surface vehicles. Articles by Laxmidhar *et al.* and Tan *et al.* describe applications of ALC in drones specifically autonomous quadrotors. Wang *et al.* present an article for spacecraft systems. In this Special Issue, a leader-following event-triggered adaptive consensus method is developed for multiple rigid spacecraft systems.

The article by Wu *et al.* describes a Lidar-based localization scheme for unmanned ground vehicles in GPS-denied or GPS-challenged environments. They fuse the Lidar information with the inertial measurement unit. A related article is by Gu *et al.*, which describes a path-tracking control method for autonomous vehicles subject to deception attacks. The authors propose an adaptive learning-based event-triggered mechanism. Finally, Zhou *et al.* consider massive autonomous systems and propose a game-theoretic decentralized adaptive optimal tracking control method.

AHMET ENIS CETIN
Department of Electrical and Computer Engineering
University of Illinois at Chicago
Chicago, IL 60607 USA

QING-GUO WANG
Faculty of Engineering and Built Environment
University of Johannesburg
Johannesburg 2006, South Africa